

powertrain & drive focus

» THE MOMENT WE START
DEVELOPING THE BASIC CONCEPT
OF A STEYR TRACTOR, WE
ALREADY HAVE THE OBJECTIVE
TO ACHIEVE DURABILITY.«

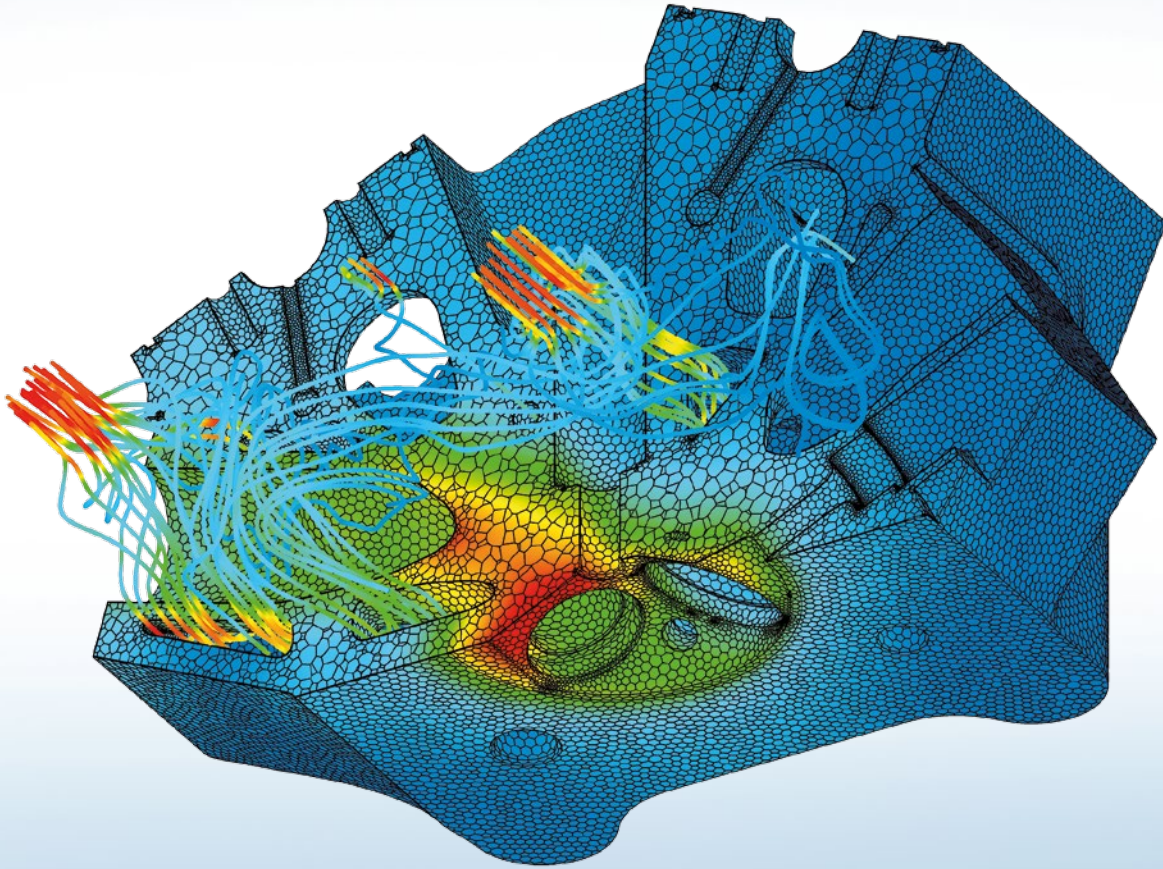
ING. ANDREAS KLAUSER, BRAND PRESIDENT CASE IH AND STEYR

.10 Story of Success with
200 kW per Liter

.18 Efficient Performance Optimization
in Large Engines

.22 Success Based on Interplay





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HyPer 200 - Story of Success with 200 Kw per Liter

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Monitoring of and Efficient Performance Optimization in Large Engines.

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With the AVL Team SUITE™, automotive developers can now draw on expert tools that are designed to handle today's complex development requirements.

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Prof.
Helmut List,
Chairman
and
CEO AVL



To ensure a strong global presence on a variety of markets, it is crucial for OEMs to offer more and more vehicle variants with a growing number of different drive systems. The challenges, which this poses to developers of vehicles and drive systems, are multifaceted. On the one hand OEMs must be able to master the sheer diversity of combinations and, consequently, their efficient and cost-saving development. On the other hand they have to achieve optimum efficiency, environmental acceptability and agility in terms of an attractive driving experience for every single variant.

Drawing on decades of experience in the field of drive system development, AVL offers innovative solutions that can help OEMs to respond to these particular challenges with effectiveness and efficiency. AVL provides support in optimizing the design and development of combustion engines and electric motors and assistance in broadening the power spectrum of engine families, thereby allowing automotive manufacturers to optimally adapt themselves to the demands of a global market.

Based on our close collaboration with OEMs and suppliers and our deep understanding of current and future challenges, we will continue to serve our customers by facilitating the successful implementation of drive systems which are more efficient and attractive than ever before.

Helmut List

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Interview with Andreas Klauser, Brand President of
Case IH and Steyr, and Christian Huber, Vice
President of Global Tractor Product Management

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► **«F»:** Mr. Klauser, the agricultural machinery brands Steyr and Case IH, as well as fire engine brand Magirus Lohr are based in St. Valentin. What led you to make St. Valentin the European headquarters? Is Austria known as a particularly attractive location for the agricultural machinery market, or was it rather the Austrian production quality that prompted the decision to establish your headquarters here?

«Andreas Klauser (A.K.): As a matter of fact it was a combination of various aspects. Of course one of them was that Steyr tractors have been manufactured in St. Valentin for close to 70 years. Another reason was that we are lucky to have a very sophisticated engineering unit and, from a logistical point of view, we are optimally located within Europe. Another factor was naturally the location itself, more specifically the greater area of Steyr, Linz and Wels – cities with universities and a high standard of apprenticeship training. These were some of the reasons and factors that ultimately led us to our decision of transferring the European headquarters to St. Valentin.

«F»: Mr. Huber, what significance does research and development have at Steyr and Case IH and to what extent can it be said that R&D reinforces the two brands?

«Christian Huber (C.H.): Research and development has top priority for Steyr and Case IH. It was also one of the crucial factors why an international group showed its interest in the Steyr plant. We draw our expertise from our strong legacy of innovation. Bear in mind that Steyr was one of the first companies to develop the innovative CVT technology (i.e. the continuously variable trans-

mission) and to implement it into an agricultural tractor, which was an industry first. Apart from that, our key product focus related to the Alpine environment has also evolved out of the R&D area. This particular field includes the electronically controlled front linkages that have led to improved weight compensation, superior soil conservation and maximum efficiency. Farmers in the Austrian region contribute to this legacy of innovation. As some of them have completed their professional training in the field of engineering and work at Steyr, they have the necessary know-how and understand exactly what our customers need.

«F»: Steyr is Austria's favorite tractor brand. But there must be more than just the red-white-red paintwork to which Steyr owes its success. What makes Steyr tractors so special?

«A.K.): Steyr tractors have a long tradition. While this is obviously not a guarantee for future success, it does form a stable foundation. Further success factors are the quality and the models specifically geared to the Austrian market, to be more precise, geared to German-speaking countries like South Germany, Switzerland and also Northern Italy. These markets have one thing in common: farmers are interested in extremely detailed specifications and have very specific machinery requirements. Another reason is that farmers in these markets don't want products off the shelf

but rather tailor-made machinery that matches their exact needs. This is an aspect that benefits the Steyr brand and which, as Mr. Huber has already pointed out, is specifically developed right here: in the region for the region.

«C.H.): What distinguishes a Steyr tractor? Steyr tractors are built by Austrians for Austrians. This is also reflected in research and development. The engineering center at the plant in St. Valentin might not be the engineering headquarters of CNH Industrial (which is in Modena, Italy), but it is nevertheless a very important branch for the company as a whole, for all tractors intended for Alpine farming with an exceptional level of comfort. The continuously variable transmission (CVT) and the Alpine models are further technologies that Steyr brought into the corporate group.

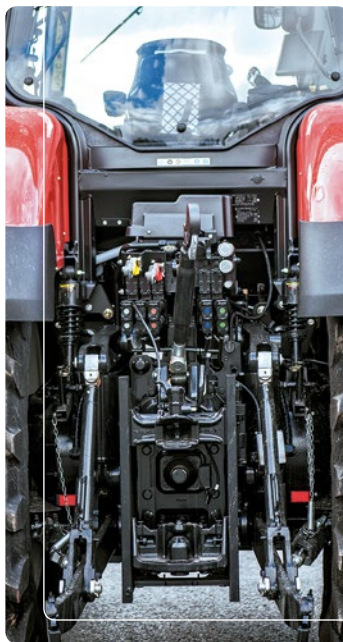
«F»: How do you think the tractor market will evolve over the next two or three years?

«A.K.): In my opinion, it won't continue to grow but rather stabilize at the same level which it was in 2015 and will be in 2016. The trend toward all-round, high-performance machinery will continue. The Steyr Terrus CVT, for example, belongs to this tractor category. The reason for this trend is that very frequently two tractors with a performance of 70 to 80 hp are replaced by one tractor with 240 hp. This is because the number of people working on farms has decreased. The older generation retires, so there is a lack of people working on the farm. The only remaining option is to use a high-performance tractor to farm the land that used to be managed by more workers and more equipment.

◀F: Buying a new tractor involves investing a significant amount of money. What are the advantages of investing in a tractor rated at 130 to 140 horsepower? How sustainable are Steyr tractors?

◀C.H.: A key factor in this respect is efficiency. What I mean is that farmers attach a lot of importance to profitability within a certain period of time. Steyr tractors provide an excellent return on investment, because the vehicle's overall concepts meet customer requirements in the best way possible. This means that Steyr tractors have the most economical engines in the entire industry. On top of that, our machinery has the most efficient transmissions – from conventional manual transmissions to semi-powershift transmissions and continuously variable transmissions (CVT) with double clutch technology. All of these aspects combined with the specific options to mount attachments to the front and rear area, four-speed power take-off, low noise level, spacious cabins, fuel saving economy mode with 50 km/h at 1,600 rpm, low fuel consumption, optimal power-to-weight ratio, etc., are most economical in Steyr tractors.

◀F: The Terrus CVT is Steyr's "flagship" and the most powerful tractor ever built by Steyr. It features multiple fuel-saving technologies, such as Steyr ecotech, which helped it win the „Machine of the Year 2016“ award. Could you tell us more about it?



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The Steyr Terrus CVT was chosen as "Machine of the Year 2016" at the Agritechnica, the trade fair for agricultural machinery and equipment in Hannover.

◀C.H.: For our customers, Steyr ecotech means that they can take advantage of the engine technology with maximum efficiency. Today, the emission limits are becoming tighter and tighter, i.e. the standards are becoming increasingly stringent in an effort to reduce CO₂ and NO_x emissions. That's why it is becoming increasingly important to bring different exhaust emission systems on the market, which satisfy these regulations. Up to Emission Stage IIIA, fuel consumption used to rise in relation to power output, and it was very difficult for

» STEYR CONSTANTLY MODERNIZES AND REDEFINES ITSELF. ◀

ANDREAS KLAUSER,
Brand President Case IH und Steyr

us to create a concept that would be good for the future and perfect for our customers. Today, with our sister-brand Fiat Powertrain (FPT), which has an extensive wealth of knowledge and experience in this area, we are capable of drawing on state-of-the-art technologies that have never before been available to the agricultural sector. By this I mean the unique exhaust after-treatment technology Hi-eSCR (Selective Catalytic Reduction) from FPT, by virtue of which Steyr tractors currently exhibit the lowest levels of diesel consumption at optimum utilization. Furthermore, Steyr Terrus CVT engines feature a variable geometry turbocharger, which, thanks to Hi-eSCR, delivers optimized response characteristics. All of this was achieved with the key milestones reached by our sister-brand FPT.

◀F: Speaking of diesel engines – an interesting topic, given the increasingly stringent emission standards: Which technologies do you think can help to further optimize the diesel engine? Are topics like electrification and hybrid drives relevant to the agricultural machinery sector?

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By virtue of innovative technologies, such as Hi-eSCR (Selective Catalytic Reduction) and ecotech, the Terrus CVT not only shows optimal response behavior across all speed ranges, it is also outstandingly fuel-efficient.



«A.K.»: Hybridization is relevant to the extent that the implements that are additionally mounted on the tractor are being electrified, so that they no longer have to be driven hydraulically. That is one of the topics we are focusing on. The other topic that is relevant to us is the use of gas as a fuel. We are investigating to what extent LPG (Liquefied Petroleum Gas) and CNG (Compressed Natural Gas) are effective fuels. So in this respect, we see the medium-term trend in drive systems moving toward gas-driven engines and electrically powered implements.

«F»: **Where passenger cars are concerned, the emotional component to buying a new vehicle is not insignificant. What do Steyr and Case IH do to add a good portion of driving fun to tractors? Do emotions play a role with tractors at all?**

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«A.K.»: First of all, we pay attention to a tractor's steering system and controllability. One of the more central components in this respect is the information system inside the cabin, which is effectively positioned and arranged. Another key factor involves the materials we use, as they enhance comfort, especially when the driver has to operate the tractor for long periods of time.

It is definitely true that there is an emotional component involved in Steyr tractors, particularly as they also have a very high resale value. In Austria this puts Steyr right on top, ahead of all its competitors. Where spare part procurement is concerned,

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one may say that second-hand Steyr tractors are still very high in demand as spare parts are still available for them. As a traditional brand, Steyr constantly modernizes and redefines itself, particularly because we want to continue to satisfy our customers in the future. This is especially important as today's generation of farmers expect the iconic tractors to be more dynamic.

«C.H.»: Tractors are increasingly becoming objects of prestige which people want to identify with. In this respect, design, styling and image are definitely major factors in the purchase decision, which play a key role for our customers. That is why our overall concept of high-tech, know-how and dynamic design is perfect for Steyr tractors. And that is also why Steyr is number one in Austria and has been so for more than 50 years.

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**PROFILE OF ANDREAS KLAUSER,
BRAND PRESIDENT
CASE IH AND STEYR**

Andreas Klauser was born in Kirchdorf/Krems in 1965 and was passionate about agricultural engineering at an early age. After graduating from HT-BLA Steyr (a higher technical school for mechanical engineering) in 1987 he completed a degree program in Export Business at the Johannes Kepler University in Linz.

Andreas Klauser began his career with Steyr Landmaschinentechnik in 1990. Until 1996 he worked as export manager for Steyr Traktoren in Italy and Eastern Europe. In the same year, he assumed the role of Business Director for Eastern Europe, focusing his work on the reorganization of distribution in Eastern Europe. Between 2000 and 2006, Andreas Klauser distinguished himself as Business Director of Central Europe for Case IH, Steyr and New Holland and as Sales and Marketing Director for Poland. Between 2006 and 2009 he held the position of Vice President and General Manager Europe for Case IH and Steyr.

In 2009, he became Brand President, taking on the global overall responsibility for the brands Case IH and Steyr, and has successfully managed the brand activities from the Case IH headquarters in Racine, Wisconsin (U.S.) and the European headquarters in St. Valentin ever since.

◀F: Mr. Klauser, in the passenger vehicle industry, connectivity between vehicle and driver is on the rise. More and more people are also talking about smart cars or autonomous cars. Is there any talk of connectivity between drivers of tractors and their vehicles?

◀A.K.: There certainly is. In smart tractors, we have incorporated connectivity to an extent that they even feature vehicle-to-vehicle communication: combine harvesters, for example, drive ahead and are followed by unmanned tractors. Just a few years ago, nobody would have cared about such technology because there were still enough tractor drivers around. But in the meantime, for example in the Balkan states, there are steadily decreasing numbers of people in rural areas who drive tractors. So connected vehicles, i.e. vehicle-to-vehicle systems, are gaining significance. AFS Connect™ (Advanced Farming Systems), for example, is GPS technology which we use in our tractors. It helps drivers make decisions: For example, how the drivers should drive and which control function they should switch on and when. When they receive a correction signal, the tractors are able to follow a row to within 2.5 cm of accuracy. These systems, in which we are market leader, assist farmers in jobs like fertilizing, planting, soil tilling or harvesting; they reduce overlap and increase not only comfort but also efficiency and the resulting potential yield.

◀F: The Steyr brand's slogan is „A tractor you can rely on.“ How does Steyr achieve the long service life for which the brand is known?

«A.K.»: The moment we start developing the basic concept of a Steyr tractor, we already have the objective to achieve durability. In doing so, we try to meet the exact needs of our customers, also by improving the materials we use. Part of our development approach is that we accept no compromises. That is the reason why the Steyr Terrus CVT has a certain power-to-weight ratio and a solid design. Here in the Engineering department in St. Valentin we additionally have part-time farmers who bring in their own experience with practical field use and the machinery. That is how we know what really matters in a tractor model and what we need to pay attention to in its development.

«C.H.»: What I believe matters most is the extent of the development, i.e. the particular process in which certain parts are designed – no matter whether these are exhaust gas systems, hydraulic systems or any other tractor components. We have exact guidelines which we resolve to follow during the development process. For example, that a tractor must be tested for 10,000 hours. We engineer our tractors according to these criteria and with all of the advanced systems available to us in the development process. There is a reason why we have the slogan „A tractor you can rely on.“ We have certain standards that set us apart from our competition, for example the quality factor to which we attach great importance. Reliability is the result of our design criteria, which allow us to manufacture a product that is durable in every way. ←



PROFILE OF CHRISTIAN HUBER, VICE PRESIDENT GLOBAL TRACTOR MANAGEMENT

Christian Huber was born in Steyr in 1962 and began his career with Steyr-Daimler-Puch AG back in 1977 when he joined the Austrian tractor manufacturer to embark on an apprenticeship as engine fitter. Having finished his apprenticeship, he worked as an assembly fitter and tester in tractor testing.

After several years of working in Sales & Marketing and as a sales trainer, Christian Huber became Global Tractor Marketing Director in 2006 and worked in Racine, Wisconsin, U.S. from 2008 to 2012.

Later on, from 2012 to 2015, he held the position of Product Line Director for Medium and Light Tractors in Modena, Italy.

In September 2013, Christian Huber was appointed sole managing director (in addition to the core function) of CNH Industrial Austria. Since 2015 he has held the position of Vice President Global Tractor Management.



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AVL HyPer 200 kW/l - supported by
Honeywell, Valeo, Nemak and BOSCH.

STORY OF SUCCESS WITH 200 KW PER LITER

With its brand new AVL HyPer 200 concept engine, Graz-based technology supplier AVL is setting new standards. Its new 1.75-liter engine, which was installed in an Alfa Romeo 4C, delivers an output of 474 hp at 8000 rpm, producing 200 kW for every liter of engine displacement. It is fitted with two exhaust turbochargers and one electrically driven compressor. In 2015, a large number of interested visitors at the Aachen Colloquium got a chance to see what the outstanding concept engine is capable of.

► The current trends on the automotive market are very clear. Due to legal requirements and customer demands, engines in the mass market segment with moderate demands on performance must prove compliance with ever decreasing CO₂ emissions. Conversely, specific torque and specific output in the flagship segment are showing a sharp rise, especially in the 2-liter class. The desire to replace six-cylinder engines with powerful four-cylinder engines, in particular, is leading to a sharp rise in specific output. Such high demands on output are creating an ever widening spread in the engine families. This calls for a high level of modularity.

EXTREME MODULARITY FOR A BROAD POWER RANGE

Engineering work on the 1.75-liter four-cylinder engine initially started when AVL teamed up with Fiat/Alfa Romeo to develop the concept of a 330 hp (139 kW/l) engine for an Alfa Romeo Giulietta, which was unveiled at the Vienna Motor Symposium in 2013. Not long after, the implementation of several optimizations led to a further upgrade of the concept engine's output to 350 hp (148 kW/l), which made quite a stir and generated a great deal of interest. At the time, the engine became known for having the highest output per liter under series boundary conditions.

This achievement was topped by Volvo and AVL in 2014, when they presented their 450-hp 2-liter concept engine. Yet it seemed to the engineers that with 450 hp and two liters of displacement (168 kW/l) they had still not reached the limit, so in 2015, AVL decided to raise the power

in downsized engines even further. "We planned to develop a high-performance concept based on an engine from the mass market segment. It was essential for us to remain within the boundary conditions for series production and the same engine family," Paul Kapus, Head of Gasoline Engine Development at AVL said, adding: "The module concept, in other words the 'engine family stretch', is explained by the fact that an entire engine family achieves both lower consumption and higher peak output levels. In addition to having common bore and stroke, the engines belonging to the same family also share the same cylinder spacing, the same cylinder head base design with the same flange positions and the same valve train. So, essentially, all of the basic dimensions are the same. As a result, all of the interfaces to the periphery remain unchanged too, both on the inlet and the exhaust side. However, these interfaces are also used to connect different kinds of turbochargers, for example," Paul Kapus said, explaining the concept of modularity.

ELECTRIC SUPERCHARGING SINCE 2002

To achieve the flagship model target of 200 kW/l in the engine family stretch, it is essential to provide additional charging because of the large turbochargers. Without this additional boost, torque and response behavior would not be acceptable at low engine speeds. Obviously, it should be the objective of a flagship engine to achieve a faster response behavior than the base model, and not just a high specific output. AVL realized this back in 2002 when the first prototype featuring electric supercharging was engineered. For that reason, a 48-volt-driven electric compressor was chosen to improve response and low end torque in the 200 kW/l concept.

From 2006 onward, AVL developed the demonstration vehicle VW Passat Electric Boost Low Cost Hybrid. This concept demonstrated that a 2l TGD engine fitted with a turbocharger and electric supercharging combined with a transmission with long gear ratios was capable of achieving fuel economy comparable to that of diesel engines in similar engine-power classes. The latest



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Volvo S60 demonstrator vehicle with 450 hp engine.

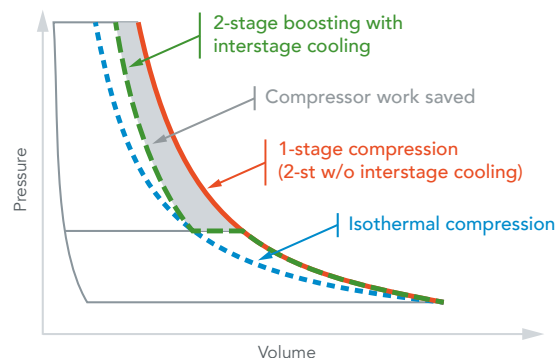


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Paul Kapus (r.), Head of Gasoline Engine Development, and Matthias Neubauer (l.), Technical Expert High Performance Engines.

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Two-stage compressor for optimum pressure ratios.



project, in which AVL used electric supercharging to boost efficiency, was the VW Golf HiEff. The aim of this concept engine was to demonstrate that by using a Miller-cycle engine with a high-pressure exhaust gas recirculation system with cylinder individual feed and an e-compressor, CO₂ emissions in the NEDC test could be reduced from 122 g CO₂/km down to 90 g CO₂/km – without requiring hybridization. The e-compressor powered by 12 volt not only takes care of electric boosting but also acts as exhaust gas recirculation pump. In this concept, engine efficiency was raised to 40% in the sweet spot.

THE AVL HYPER WITH 200 KW/L

According to Matthias Neubauer, Technical Expert for High Performance Engines, it was a particular challenge for AVL to obtain the output of 474 hp (349 kW) from a 1.75-liter engine: “The problem we faced was that we wanted to focus on durability, but without leaving the family concept. However, to achieve a good response behavior at all speeds, the mean effective pressure should not go far beyond 30 bar. Achieving the target output with-

out exceeding 30 bar mean effective pressure requires an engine speed of 8000 rpm. The engine could also have been designed for as little as 6000 to 6500 revolutions per minute, but this would have required a mean effective pressure level of around 40 bar. Yet on the one hand this would have led to slower response behavior and on the other the torque demands placed on the remaining powertrain, such as clutch and transmission, would have been too large and we did want to use series components for clutch and transmission.”

To make the engine durable at speeds up to 8000 rpm, we first had to take development measures to make the engine speed-resistant. For this purpose, our optimizations focused on the crankshaft, rods and pistons, which were provided with special cooling galleries, and the valve train. Apart from that, an improved cylinder head cooling system with cross flow concept was designed to help the engine withstand the extremely high thermal loads at maximum output: “It was crucial to give the cylinder head a design that would allow it to dissipate the high thermal load. This is essential for knock resistance and also durability. Obviously, an engine with such a high power density has an extremely high heat input – similar to that of a V8 bi-turbo engine, but in our case distributed across no more than four combustion chambers,” Matthias Neubauer explained.

By utilizing a special fuel injection system from Bosch, designed for 350 bar, sufficient fuel flow was ensured – while maintaining strict compliance

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High-performance
engine with bi-tur-
bocharger and two-
stage compressor.



with the Euro 6c regulations. I.e. the vehicle was designed in such a way that it will also comply with the latest RDE limits. Two Honeywell turbochargers with two-stage compressor in bi-turbo arrangement ensure that the necessary boost pressure and mass flow is achieved without causing excessive temperatures at the compressor outlet. In addition, the two-stage compressor delivers a very broad compressor map while maintaining good efficiency. The one-stage turbine ensures low backpressures and thus a low residual gas level in the cylinder. This, in turn, reduces the tendency for knocking. Furthermore, a Honeywell 48-volt e-supercharger supports the turbochargers, ensuring a fast response time at low and high engine speeds.

“Two-stage compression is far more efficient because it brings the process closer to isothermal compression.”

This saves a lot of work in the compression process and results in compression ratios higher than four at moderate compressor outlet temperatures,” Paul Kapus explained. Expressing his thanks for the successful collaboration, he added: “The AVL HyPer 200 project was supported by Fiat Chrysler Automobiles, Honeywell, Bosch, Valeo and Nemak. AVL would like to take this opportunity to say ‘thank you’ for the good collaboration. Special thanks also go to Dirk Andriess, former Chief Engineer, as well as Stefano Quinto, Chief Engineer, and Sabino Luisi, Assistant to Chief Engineer, from Fiat Chrysler Automobiles, who made this collaboration possible in the past few years.”

What started with the 330-hp Giulietta, which AVL and Fiat/Alfa Romeo presented at the Vienna Motor Symposium in 2013 and was known for having the highest specific output ever to be achieved by a four-cylinder engine and later on evolved into the Volvo S60 with 450 hp, has become a real story of success. The AVL HyPer 200 kW/l is proof that the upper limit for specific output in series engines has still not been reached. With a vehicle weight of around 1000 kilograms and an engine output of 474 hp, AVL has come up with a convincing overall package that has the potential of becoming a trendsetter. Paul Kapus on the significance of the project: “Having gained so much experience with peak-power concepts, we were able to show that within the context of a modular family concept with an electrically supported charging system it is indeed possible to meet the demand for more peak power in downsized engines.” ←

To meet the increasing global transportation demands combined with lower fuel consumption and lower emissions, it is essential to optimize the system holistically. AVL has development tools and experts needed for the optimization of complete commercial vehicles systems.

COMPLETE SYSTEM OPTIMIZATION ENHANCES EFFICIENCY IN COMMERCIAL VEHICLES

BENCHMARKS SERVE AS OBJECTIVE BASIS FOR POSITIONING

In benchmarking different vehicles are measured in detail and rated to determine values for their levels of performance, drivability, fuel economy and emissions. AVL-DRIVE™ assesses performance (including drivability) as well as efficiency and emissions. Even the performance attributes receive an objective description. This is done by comparing the vehicles with current truck data using so-called scatter bands. The target values are described objectively and the necessary improvements are precisely specified as system requirements.

Gerhard Stempfer, Head of Commercial Vehicle System Development, explained: “Having defined the targets for a complete system optimization, we derive the individual component requirements and work out how they can be optimally tuned.”

ANALYZING VEHICLES AS COMPLETE SYSTEMS

Gernot Hasenbichler, Product Manager Commercial Vehicle On-Road, explained further: “Many years ago, we recognized that it wasn’t really possible to view axle, transmission, electrical components, software and the internal combustion engine separately. To be able to give our custom-

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Achieving goals with in-depth component know-how and system knowledge.

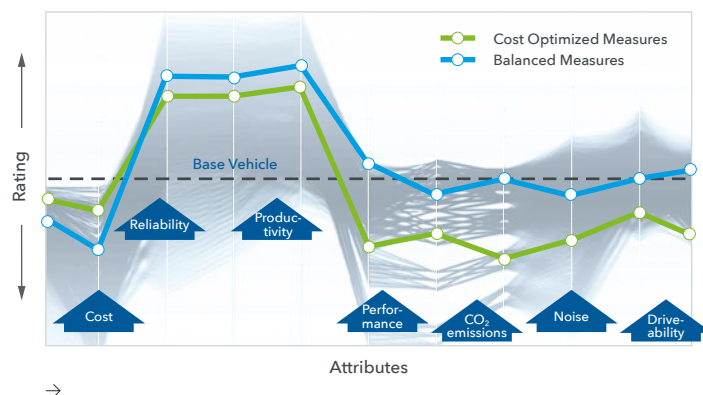
ers expert advice, we need to analyze and understand the complete vehicle and its application. No matter how good the built-in vehicle components are, if they are not optimally tuned to the application, their potential will remain unrecognized. That is why here at AVL, we use both our in-depth component know-how and our system knowledge to design and integrate them into the overall system in the best possible way.”

CO₂ EMISSIONS LEGISLATION – LIMITS AND ZERO EMISSIONS

In markets like the U.S., Japan or China, the CO₂ emission regulations are already in force in their first phase, and in Europe legislation proposals are in their evaluation phase. So with regard to the CO₂ limits, which are in the process of gradual decrease, overall system analysis will be a crucial factor in goal-oriented technology selection. This is because, depending on the application and vehicle class, optimized conventional, hybrid and fully electric powertrain technologies will be used.

“ATTRIBUTE BALANCING” FOR OPTIMUM BALANCE OF VEHICLE CHARACTERISTICS

The newly developed method of “attribute balancing” enables the definition of the optimal technology mix for a certain vehicle class and application regarding the required targets. In the world of commercial vehicles “optimal” means achieving performance targets with a successful business case enabled with the lowest possible development- and product costs.



Attribute Balancing for the optimal technology mix.

SIMULATION FOR A BROAD VARIANT DIVERSITY

To evaluate the relevant overall system optimization technologies in the context of attribute balancing, and to develop concrete concepts including their attributes, AVL works with state-of-the-art simulation tools such as AVL-DRIVE™, AVL CRUISE™, AVL VSM™ or AVL EXCITE™. As Gernot Hasenbichler explained, “These tools allow you to rate the different targets and attributes already in the virtual world, and work out the best match of technologies and their configuration for the application.”

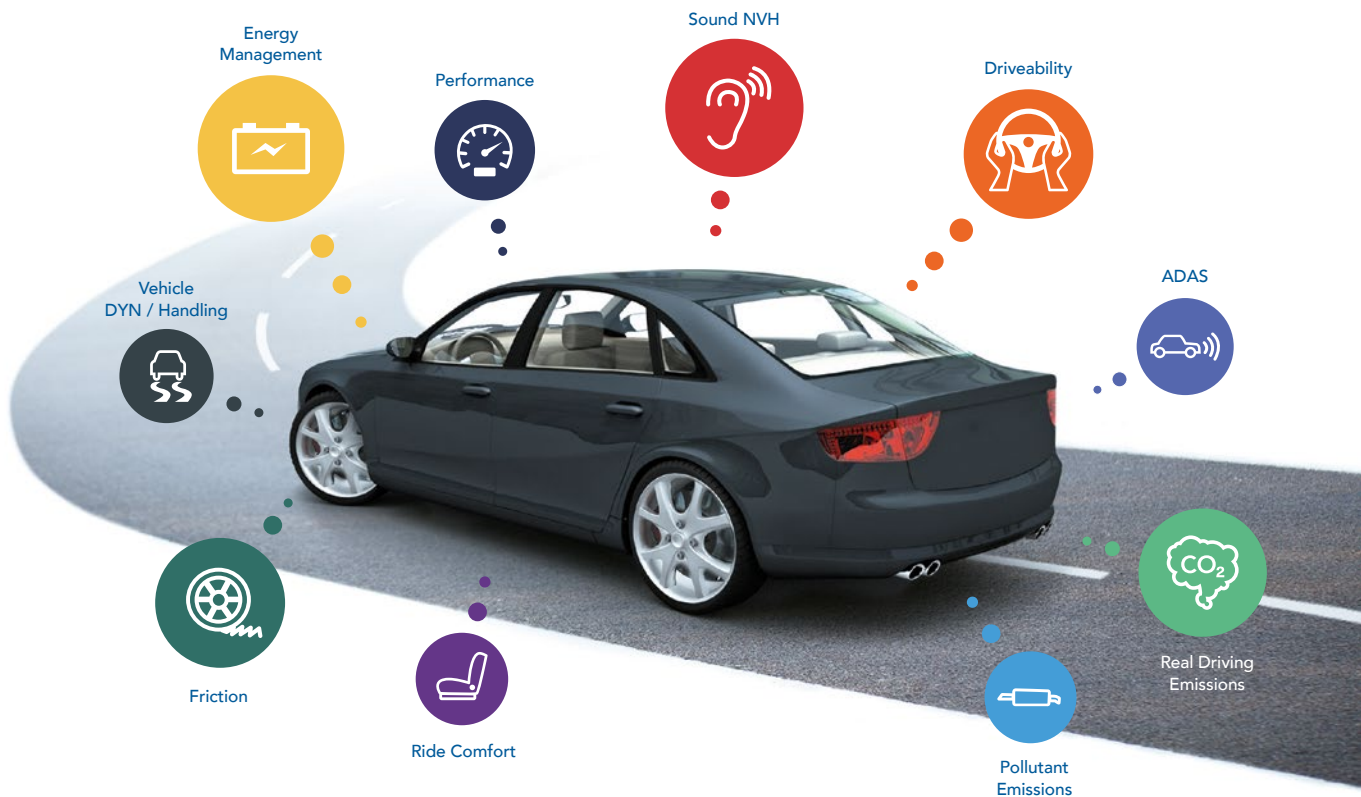
TECHNOLOGY TRENDS

Given the increasingly stringent exhaust emission regulations, the experts at AVL are certain about where the future technology trends in the commercial vehicle industry are heading: Electrification will for sure find its way into most of the

markets. Depending on the application, different degrees of electrification will be implemented. Electrified auxiliaries are expected to catch on in most markets, with full hybrids and electric vehicles being operated in urban areas due to local legislations and zero emission zones. Particularly in the field of long-distance transport, however, the optimization of the internal combustion engine and the conventional powertrain will remain a central challenge.

AVL OUTLOOK ON SYSTEM OPTIMIZATION IN COMMERCIAL VEHICLES

The system development for commercial vehicles combined with its tools and detailed knowledge of the five powertrain components give AVL a strong unique selling point. The next step will be to gradually roll out these fields of expertise and services globally – beginning with benchmarking and “attribute balancing” up to the integration of conventional, hybrid and fully electric powertrains in vehicles. ←



NEW AVL-DRIVE™ MODULES REVOLUTIONIZE VEHICLE DEVELOPMENT PROCESS

When it comes to enhancing efficiency and quality in the drivability design process, numerous OEMs and transmission manufacturers rely on the established expert tool AVL-DRIVE™. Featuring new modules for the objective evaluation of driver assistance systems, handling, suspension comfort, CO₂, efficiency and emissions, AVL-DRIVE 4.0 now provides developers of vehicle functions and components with a highly efficient development method.

► In its fourth generation, AVL-DRIVE 4.0 allows vehicle and powertrain development engineers to objectively assess and design a great number of subjectively perceived vehicle attributes. Christian Juwan, Product Manager Drivability and Simulation: “The objective assessment of drivability and vehicle attributes, such as performance, handling, driving comfort, ADAS functionalities, as well as the documentation of features such as cycle consumption (CO₂), cycle emissions, real consumption, RDE (Real Driving Emissions) and energy efficiency, is conducted by using the new AVL-DRIVE 4.0 modules.”

The AVL-DRIVE 4.0 modules for longitudinal, transversal and height dynamics, as well as driver assistance systems, can be used individually or in combination for the targeted optimization of vehicle attributes. This allows the development of vehicles with characteristic features that are harmoniously tuned.

In combination with powerful simulations, these objective assessments permit the targeted optimization of vehicle attributes at early design stages, delivering the key to higher efficiency in complete vehicle development.

ENHANCED DEVELOPMENT EFFICIENCY BY COMBINED FRONTLOADING

By combining AVL VSM 4™ and AVL-DRIVE 4.0, engineers can use vehicle and environment simulations to rate, vary and optimize the effects of CO₂ and emission-reduction measures on drivability, driving dynamics and driving comfort at an early stage in development.

The joint use of simulation and AVL-DRIVE 4.0 modules boosts ef-

ficiency in vehicle development even further. As Christian Juwan explained, describing the benefits of the innovative method, “AVL-DRIVE 4.0 can be used throughout the development process to optimize not only driving attributes but also a vehicle’s CO₂, fuel economy and real driving emissions. The method finds application in pure simulations on the office PC, in test bed environments and even on the road. So the objective assessment of virtual prototypes helps you detect any counterproductive vehicle configurations very early on in development.”

THE NEXT STEP

Moreover, AVL is already working on the enhancement of AVL-DRIVE 4.0. The ever more stringent legal requirements, the progressive electrification and future autonomous cars are leading to a level of technical complexity that is becoming increasingly difficult to handle. In this regard, the “event finder” approach is one of AVL’s key focuses to provide a tool that helps OEMs to continue to analyze and optimize the growing number of parameters holistically. ←



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AVL-DRIVE 4.0 supports the entire vehicle development process - from road to rig.



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AVL VSM 4™ (Vehicle Simulation Model) for more driving pleasure.

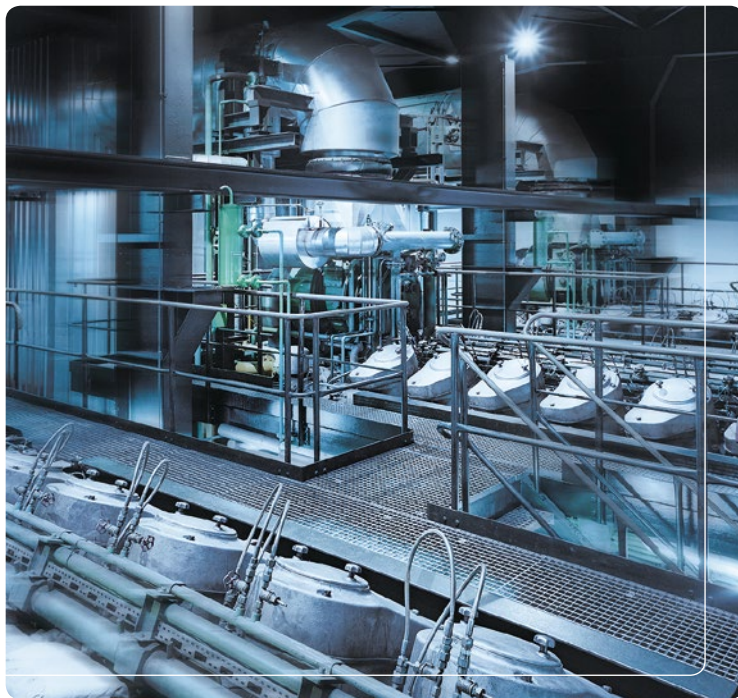


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AVL-DRIVE 4.0: Comprehensive and objective vehicle benchmarking.

EFFICIENT PERFORMANCE OPTIMIZATION IN LARGE ENGINES

AVL EPOS™ is an expert tool that was developed by AVL, and helps operators of large engines to prevent costly engine damages and enhance efficiency.



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Partial view of a ship's engine.

► In view of long-term profitability, efficiency, safety and maintenance considerations, condition monitoring in large engines poses a huge challenge for operators of large engines. This is because troubleshooting, malfunctions or any

resultant engine damage is frequently associated with high costs and time-consuming procedures. Apart from that, analyses have shown that engine damages are either linked to the combustion process itself or to large engine com-

ponents that have an impact on combustion. This is often the case if injection processes, fuel, cylinder, piston or cylinder head were insufficiently monitored. However, the early detection of combustion abnormalities can help to optimize operation, reduce fuel consumption, schedule preventative maintenance and thus to significantly extend service life of large engines.

TEN YEARS OF POOLED EXPERTISE

Due to AVL's extensive experience in the fields of large engines, development tools and test systems, AVL's combustion diagnostics systems have a high reputation on the market. For this reason, in 2006, AVL developed an innovative tool that can monitor combustion processes in engines efficiently on a continuous basis. The idea was to not only provide a pure measuring system for combustion processes but to include a built-in analysis tool and a function that assists operators of large engines in further procedures. "AVL EPOS™ is a product that was only possible by incorporating pooled know-how from the fields of powertrain



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AVL EPOS™

engineering and indicating equipment right from the start,” Rüdiger Teichmann, Global Segment Manager at AVL, explained.

“AVL EPOS™ is not only capable of monitoring and measuring the pressure inside the combustion chamber. The system can also detect combustion faults early on and suggest troubleshooting solutions,” said Hinrich Mohr, Product Manager of System Integration, Large Engines, at AVL. One of the challenges the experts faced when developing AVL EPOS™ was that the required sensors have to be capable of meeting minimum service life requirements of 20,000 hours and withstanding temperatures of up to 400 °C. With conventional quartz crystal sensors this could not be accomplished, since quartz itself is only suitable for temperatures not exceeding 275 °C. However, a piezoelectric material – developed by AVL and called gallium orthophosphate – delivered the solution. Cylinder pressure sensors made of this material can effortlessly withstand temperatures of up to 400 °C. As Rüdiger Teichmann pointed out: “We have installations

on a ship fitted with AVL measuring equipment (including the sensors), which have been in continuous operation since 2008. This and other successful installations confirm the high service life of AVL sensors.”

CLEANER AIR IN EMISSION CONTROL AREAS

Apart from the beneficial functions of monitoring the continuous operation of large engines and detecting combustion faults early on, the innovative solution AVL EPOS™ can also be used to calculate emissions. Rüdiger Teichmann explained: “AVL EPOS™ is provided with a module that uses the measured combustion pressure to calculate the NO_x emissions of each cylinder and, consequently, those of the entire engine. Emission levels are also crucial for ships. If a ship passes through an emission control area, AVL EPOS™ lets you determine whether or not the ship is within the permitted emission limits. This allows the ship operators to comply with the permitted limits and to ensure optimum engine

performance in terms of emissions at the same time. Moreover, the use of AVL EPOS™ not only saves fuel but also helps to reduce the impact of harmful emissions on the environment.”

VERSATILE APPLICATION

Another customer – a Brazil-based energy supplier – also had the opportunity to experience the benefits of AVL EPOS™. As part of a joint project with AVL, AVL EPOS™ was successfully integrated into a large engine used for electricity production. According to Rüdiger Teichmann, AVL EPOS™ enabled the customer to monitor combustion processes and to balance cylinder variation, if needed. This way, significant fuel savings with the best possible engine settings can be achieved. Thanks to the function of early fault detection in combustion processes, it is additionally possible to plan preventative maintenance work early on. “Algorithms are provided, which allow an assessment of the engine’s condition. This allows operators of large engines to quickly and effectively identify malfunctions,” added Hinrich Mohr. Due to these benefits for the Brazilian customer, AVL has received the order to equip all engines at the power station with AVL EPOS™. ←

The Trend Conference in Graz

POWERTRAINS FOR THE CHINESE MARKET: A CHALLENGE FOR THE GLOBAL AUTOMOTIVE INDUSTRY

The 28th International AVL Conference "Engine & Environment" will take place in the Helmut List Hall in Graz, Austria, on the 9th and 10th of June 2016.

► China has become the world's largest and also highly attractive vehicle market. However, it is also characterized by extremely high market dynamics: Customers' buying behaviour, fuel economy and emission legislation, plus state interventions are subject to frequent changes. Moreover, recent car sales statistics indicate some market uncertainties. Possessing a comprehensive insight into the specific economic framework and the dynamics of the Chinese market is therefore one of the greatest challenges affecting the development of global powertrain technologies, and is a basis for economic success in this market.



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This year's conference will again be attended by many experts from the automotive industry.



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Scan QR-Code and access the app.



ENGINE & ENVIRONMENT

These and many more topics will be discussed by international experts at the 28. International AVL Conference "Engine & Environment".
For more information and registration visit: www.avl.com/engine-environment-2016; event@avl.com. ←



AVL ADVANCED SIMULATION TECHNOLOGIES USER CONFERENCES 2016

► Participants from the world's leading automotive manufacturers, suppliers and research institutes will get a profound insight into how simulation is driving powertrain development at one of the Advanced Simulation Technologies User Conferences - taking place at AVL locations worldwide in 2016. Make use

of these unique platforms to discover best practices, gather the latest information about current simulation software developments and experience a mutual know-how exchange with users and developers of AVL's Advanced Simulation Technologies simulation and analysis software.

Seoul, Korea: June 21, 2016

Changsha City, China:

September 21-23, 2016

Munich, Germany:

October 25-26, 2016

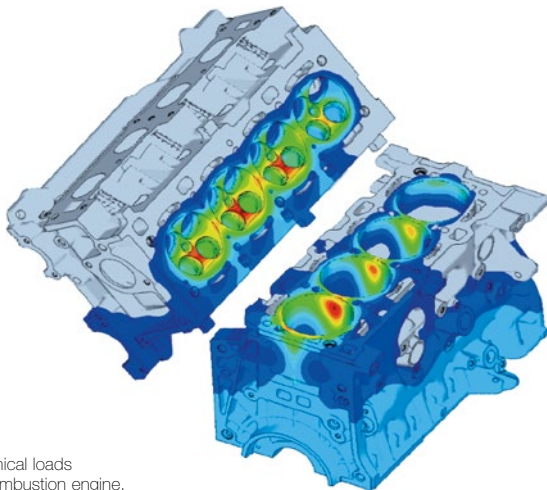
Tokyo, Japan: November 8, 2016

Pune, India: November 23, 2016

The next AVL AST International User Conference is scheduled for June 27-29, 2017 in Graz, Austria. ←

MULTI-DISCIPLINARY THERMO-MECHANICAL SIMULATION

Powertrain components must satisfy increasingly stringent demands in view of performance and durability while maintaining optimal cost efficiency. Coupling AVL EXCITE™ and AVL FIRE™ has now made thermal load calculation more accurate than ever.



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Thermo-mechanical loads
in an internal combustion engine.

► Downsizing and downspeeding are current trends in engine development. Combined with increased power and torque, they lead to higher mechanical and thermal loads up to the point of component failure. Components at particular risk are the piston assembly, the cylinder head and the cylinder block.

Numerical simulation allows detecting thermally critical areas at different operating loads at early development stages and defining countermeasures

in the form of design adaptations. For a reliable prediction of component temperatures it is necessary to analyze the heat release inside the combustion chamber, the heat transfer through the structure to the coolant and possibly the cooling of the piston. Consideration must also be given to the thermal flows between piston, piston rings and the cylinder liner, along with the additionally generated heat input from friction between the piston, rings and liner.

One of the more established thermal analysis methods used for cylinder head/block compound analysis is the so-called fluid-structure-interaction (FSI) analysis. This technique uses CFD software to calculate the in-cylinder flow, as well as the flow in the cooling water jacket and the related heat transfers to neighboring structures. These results serve as boundary conditions for calculating heat transfer and temperature distribution in the engine components. For the heat flow between the piston, piston rings and the cylinder liner usually assumptions are made based on empirical models. Consequently, there is a high risk of not achieving the level of result accuracy needed for damage prediction.

For this reason, AVL has made some significant improvements to the traditional calculation methodology. Instead of adopting an empirical approach to determine the heat flows between the piston assembly and the cylinder liner, the structural dynamics analysis software AVL EXCITE™ is used, which relies upon detailed physical models to calculate piston and piston ring contacts. This approach also implicitly takes into account the dependency of the heat flow on gap widths, the amount of oil in the gap, relative motions as well as friction heat and temperature differences between the component surfaces. In combination with the CFD software AVL FIRE™, this results in consistent numerical modeling with improved reliability and accuracy.

Furthermore, AVL FIRE™ facilitates the simultaneous calculation of coolant flow and the temperature field within the engine components. Since an additional finite element analysis is no longer needed, this represents a major simplification of the calculation process. ←



SUCCESS BASED ON INTERPLAY

In view of ever more stringent legal standards and evolving market requirements, the automotive sector is confronted with increasingly complex development tasks. With the AVL Team SUITE™, automotive developers can now draw on expert tools that are designed to handle today's complex development requirements. This is why development engineers at one of our leading customer sites in Germany decided to rely on individually combinable automation solutions for AVL measurement and testing systems.

► The AVL Team SUITE™ is a set of 15 instrumentation and test system software products that are compatible, flexible and can also be used individually. More specifically, it is a collection of tried and tested expert tools that are used in areas such as automation, calibration, simulation, control, certification, data management and data analysis, as well as test process management. The software can be customized to suit the specific needs. Its development was a response to the growing need for solutions that are able to handle the challenges not only resulting from the steadily increasing level of complexity in automotive systems, but also from the specific instrumentation and test systems.

We talked to Michael Conrad, Director of Portfolio Management, Instrumentation and Test Systems: “All of the software applications featured in the AVL Team SUITE™ are tuned to one another and are perfectly in line with uniform operating philosophies. Based on a thorough analysis of different user behaviors, and by involving usability experts and key customers in the development of the Team SUITE™, we managed to considerably improve the efficiency in which each individual product is used.” For example, development engineers who have to check the results on the test bed and are required to deliver fast and accurate results to their customers will benefit from being able to accomplish this with a consistent tool, as this allows them to take full advantage of synergies in the evaluation, and also avoid any transfer-related errors – and consequently additional work and expenses. “This



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Powertrain Development is a team sport.

is also about system performance. If development tasks are very demanding, the expert tools have to be able to interact in the best way possible. This is why the Team SUITE™ has high-performing interfaces between each of the software products, enabling new development methods,” Michael Conrad added.

SUCCESS BASED ON OPTIMAL INTERPLAY

To make working with AVL Team SUITE™ software products stress-free and efficient, the experts at AVL came up with the idea of combining the individual software products into a suite. Michael Conrad: “The AVL Team SUITE™ stands for flexibility and a high level of customization. Depending on the development tasks at hand, the products can be combined to suit the purpose – which is very similar to a team of players in a sports competition. Exhaust emissions certification, for example, requires different abilities than calibration would, however there are some components in the two processes that are iden-

tical: for example, if, already during the calibration procedure, you want to analyze and understand how your calibration may affect emission behavior later on in the certification test,” the expert said. Accordingly, the term ‘team’ refers to a high level of compatibility between individual, efficient software systems, which, combined with other platforms (e.g. test systems and equipment), unleash their full power during the entire verification & validation process.

Although combining AVL Team SUITE™ products leads to maximum performance, it is also possible to integrate third-party products too. This is because the AVL Team SUITE™ supports all of the known standards, such as ASAM ODS or ASAM ACI, and plenty of open interfaces for integrating measuring and testing devices.

CUSTOMER PROXIMITY AND AGILE SOFTWARE DEVELOPMENT

To offer our customers maximum combination flexibility, individual



» IT'S NOT JUST ABOUT HOW POWERFUL CERTAIN INDIVIDUALS OR TOOLS PERFORM, IT IS ABOUT HOW WELL THEY FUNCTION AS A TEAM WHEN FACED WITH COMPLEX DEVELOPMENT TASKS. THIS IS THE ONLY WAY TO CLEARLY STAND OUT FROM THE COMPETITION. «

MICHAEL CONRAD, DIRECTOR OF PORTFOLIO MANAGEMENT,
INSTRUMENTATION AND TEST SYSTEMS

AVL Team SUITE™ solutions are provided along the same principles as with vehicle development: "First of all, the demands are defined at system level and subsequently broken down to the individual products and implemented. Functionality is ensured in accordance with the V-process, first at component and product level, and then at the overall system level. To validate the system, we operate a separate test facility with real and virtual test beds, which we are planning to expand even further. Here we also validate the compatibility between the system and the hardware components used with the measuring and test systems," Michael Conrad said.

To be able to respond flexibly to evolving customer requirements, AVL has additionally introduced an agile software development process, which has also reduced the products' innovation cycles very substantially. In this regard, the technology supplier works very closely with its customers. "When we provide our

solutions, we make an effort to involve the end-users in our activities. Otherwise we would not be able to take the needs of our customers into account early on in development. Where the solution's design and usability is concerned, we also collaborate closely with usability experts," Michael Conrad explained, adding: "The concept of building a consistent solution out of a 'team' of efficient and user-friendly software products provides customers with a broad variety of advantages and meets the following objectives: maintenance of consistency in user experience, confirmation of overall system quality in order to ensure consistent roadmaps and life cycles, use of common structures, support of model-based development, achievement of maximum compliance with standards and legislations and the possibility of technology support. In addition, the Team Suite aims at maximized functionality in the products to ensure excellent interplay between the equipment and the subsystems."

FUTUREPROOF AUTOMATION SOLUTIONS FOR KEY CUSTOMERS

Following the end of Windows XP support in April 2014, a key customer was required to upgrade its automation system on the engine test beds prematurely and define a futureproof solution for its development needs. This led to a close collaboration with AVL. Jörn Rosenberg, Regional Business Manager of Powertrain Test Systems Europe: "We had been working with this key customer for quite some time. Following a very demanding update from AVL PUMA Open™ 1.3.0 to PUMA Open™ 1.3.2, we agreed on specifying a new and futureproof automation solution. For that purpose, we worked very closely with our customer for several years. There was a need to define solutions with various different specialized departments, which included indicating measurement technology on the one hand, and calibration on the other. It was crucial to achieve optimum interac-

» FOLLOWING A VERY DEMANDING UPDATE OF AVL PUMA OPEN™, WE AGREED ON SPECIFYING A NEW AND FUTUREPROOF AUTOMATION SOLUTION. FOR THAT PURPOSE, WE WORKED VERY CLOSELY WITH OUR CUSTOMER FOR SEVERAL YEARS. «

JÖRN ROSENBERG, REGIONAL BUSINESS MANAGER
FOR POWERTRAIN TEST SYSTEMS EUROPE



tion between the software products AVL CAMEO™ and IndiCom™ as well as AVL PUMA Open™.”

When integrating the Team SUITE™, the aim was to achieve a seamless implementation of the AVL software products. Explaining the goals of the collaboration, Jörn Rosenberg said that the joint ob-

jective with their customer was to ensure maximum test bed runtime. “Apart from that, it was essential to define an automation solution with AVL PUMA Open™ that would make it even easier to achieve results during test bed measurements. I.e. we wanted to enhance efficiency, but at the same time improve the ease of use and platform consistency.

This would never have been possible without working closely with our Germany-based key customer.”

In automotive development, the ability to respond to market requirements in a flexible manner has thus become a crucial factor. The AVL Team SUITE™ can lastingly pave the way for future development methods. Michael Conrad: “It’s not just about how powerful certain individuals or tools perform, it is about how well they function as a team when faced with complex development tasks. This is the only way to clearly stand out from the competition.” <



The automation platform AVL PUMA Open™



USING AVL CRETA 4™ FOR CHASSIS DEVELOPMENT AT PORSCHE

Reliable processes and efficient calibration data management allow Porsche engineers to focus on what matters most: ensuring that control systems are optimally tuned for a truly unique sports car experience.

► Racing track performance and long-haul comfort – Porsche developers have mastered this balancing act by integrating cutting-edge electronic control systems into a perfectly tuned mechanical chassis. In the past years, for instance, purely passive components were successively replaced by active and semi-active systems. Examples for this trend are active rear steering, electronic shock absorber adjustment or active an-

ti-roll control, to name but a few. Whether or not these technologies can reach their full potential within the vehicle lastly depends on the way the control units are calibrated. The system behavior is precisely tuned to every available vehicle variant by establishing the optimal value for all control unit parameters.

In doing so, every single vehicle version receives its very own electro-

nic DNA – a tremendous effort for the sports car manufacturer which is known for its broad variant diversity. In the course of development, massive volumes of calibration data are generated, and the engineers must ensure that only the best possible parameter settings find their way into the series vehicle. For this purpose, the work accomplished by the various calibration teams, each responsible for one control unit, is

merged on a regular basis. Frequently, trade-offs have to be made as certain parameter settings may easily lead to conflicts in interaction with other control systems. In such cases, it is critical to maintain an overview. "In the past, we managed our calibration data manually," Porsche development engineer Michael Rathfelder explained, adding: "Data was saved locally, for example in Excel tables, and shared via e-mail. Administering the data was extremely time-consuming. Process reliability was not ensured."

AVL CRETA™ – MORE THAN JUST A CENTRAL DATABASE

So as not to be swamped by data, the chassis developers eventually decided to switch over to a professional calibration data management solution around two years ago. Similar to their powertrain development colleagues, they now work with AVL CRETA™, a member of the AVL Team SUITE™. AVL CRETA™ is an easy-to-use lifecycle manage-

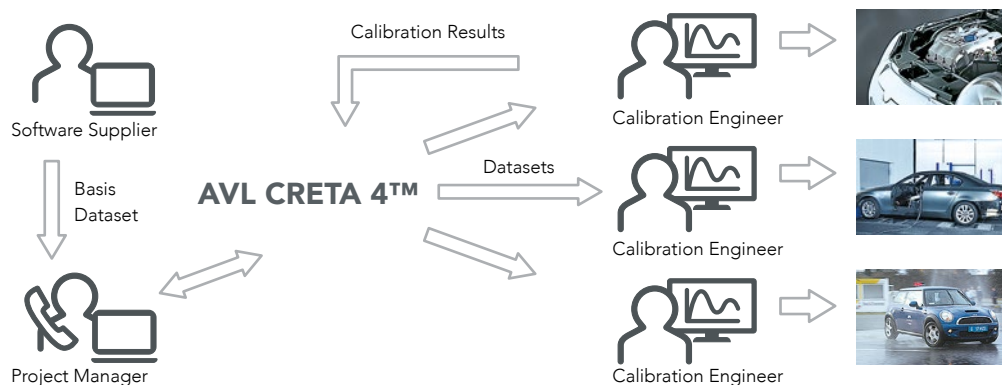
ment system which fulfills the need for fast, flexible and secure processes. The software serves as a central platform, from which all team members draw their application data, and where they check in again after processing. The calibration data is automatically subjected to versioning and the engineers can see at one glance which parameter sets are incorporated into which variant. Upon their delivery, work results are automatically checked to prevent any erroneous or overlapping calibrations from being stored in the database. This way data management costs are reduced significantly.

AVL CRETA™ supports the application process at Porsche all the way from the very first calibration to the final go-ahead for start of production. At the initial calibration, data-mining algorithms are applied to automatically generate new calibrations from existing datasets. Existing know-how is reused with maximum efficiency. Subsequently, the responsibilities for the parameters are defined among the calibration teams.

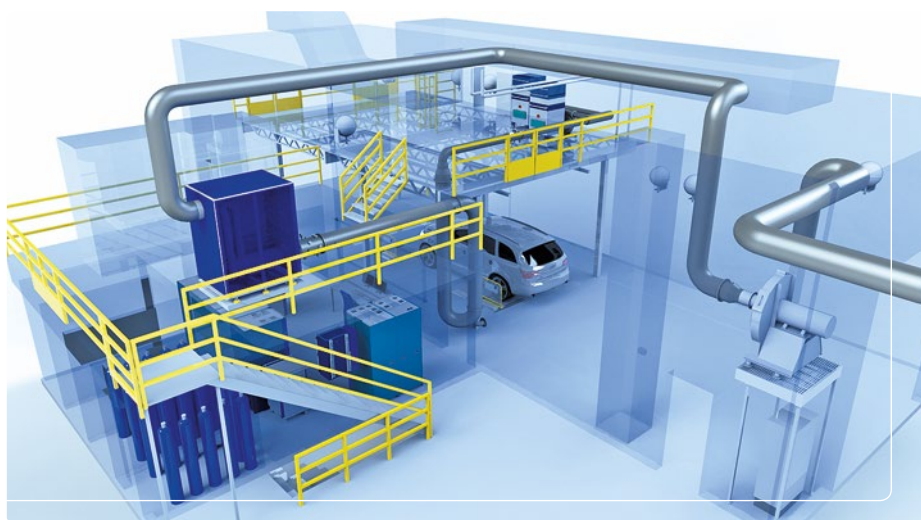
PROCESS RELIABILITY AND HIGH DATA QUALITY

Team members have global access to the data, regardless of whether they work at the test bed or on the proving ground. At defined points in time, the data manager merges the delivered results and checks the overall result. Any conflicts occurring, for example, because different calibration teams require different optimal values, are escalated and resolved. After that, the new data is released in AVL CRETA™ for further processing. This procedure ensures that all team members are always working with the very latest data version. "Thanks to AVL CRETA™ our calibration processes run very smoothly," Michael Rathfelder said. "Now we can retrace which parameters were defined for which vehicle variant anywhere in the world at any given time and are always provided with a complete history. This means we can fully rely on the quality of our data." ←

AVL CRETA 4™ APPLICATION PROCESS EXAMPLE



AVL CRETA 4™ helps reducing data management costs by up to 50 percent, and is highly intuitive and easy-to-use.



A computer model of the new Emissions Chassis Dyno at the National Vehicle and Fuel Laboratory in Ann Arbor.

AVL DELIVERING HIGH-END TECHNOLOGY TO US EPA

AVL is delivering another tailor-made emissions chassis dynamometer to an EPA laboratory in Ann Arbor, Michigan, U.S., which will allow the testing of low-emission motor vehicles and the advancement of the exhaust emission legislation in view of future requirements.

► Since the early seventies, the American environmental agencies CARB (Californian Air Resources Board) and the EPA (Environmental Protection Agency) have been global pioneers when it comes to tightening exhaust emission standards. To develop and review these regulations, the EPA operates the NVFEL (the National Vehicle and Fuel Emissions Laboratory) in Ann Arbor, where a new system will be focused on fulfilling the next reduction stage (Tier 3) for exhaust emissions in passenger vehicles (light and medium duty). This reduction stage will enter into

force in 2017 and requires high-precision measurement equipment and state-of-the-art exhaust emission automation technology.

CHASSIS DYNOS FOR EMISSION TESTING AT THE NVFEL

Until 2011/2012, the NVFEL had six test cells, each fully equipped with instrumentation and test systems provided by a Japanese competitor. However, with its introduction of the AVL iGENERATION product family, consisting of the

AVL AMA i60 exhaust measurement system, the AVL CVS i60 exhaust gas dilution system and the AVL PSS i60 particulate sampler from 2008 onward, AVL defined a new standard for combustion engine certification. The addition of the AVL SESAM i60 FT (FTIR-based exhaust emission measurement system for up to 30 gas components) along with its test bed automation systems AVL iGEM Vehicle/Engine for chassis and engine test beds to the product family led the NVFEL to decide in favor of AVL's powerful solutions for the first time in 2011.

In fall 2015, AVL was awarded the contract for NVFEL's latest showcase project: a test cell to be newly equipped for measuring the smallest concentrations of vehicle emissions in accordance with the newest EPA testing procedures. A key criterion for selecting AVL as technology partner was its ability to meet the technical demands placed on the measuring equipment and the automation system. The capability to test hybrid and pure electric vehicles apart from conventionally powered vehicles, and to design and evaluate test runs in a flexible manner were further reasons for awarding AVL the project.

CUSTOMIZED HIGH-END MEASURING TECHNOLOGY

To achieve optimal test bed operation, the complete test cell was equipped with high-end measuring technology. And this is where the iGENERATION Series II comes into play. Its heated exhaust gas measurement system with stainless steel tubing allows measuring super ultra-low concentrations of carbon monoxide (CO), total hydrocarbons (THC) and nitrogen oxides (NO_x). To fulfill the latest US greenhouse gas regulations, the system is equipped with gas chromatography technology for measuring methane (CH₄), and with a quantum cascade laser (QCL i60) for detecting nitrous oxide (N₂O).

As the new test bed is also intended for testing SUVs and vans, AVL is also supplying the CVS i60 SII MD exhaust dilution system, featuring a flow rate of up to 60m³/min and four switchable venturis, as well as a FlowSonix, a dilution air flow measurement system with pressure-

controlled mixing point. Particulate measurement in diesel and GDI vehicles is accomplished with the AVL PSS i60 SII DD particulate sampler (double dilution). Test bed automation is based on the innovative AVL iGEM Vehicle automation system for emission testing, which meets the EPA testing requirements thanks to its 1066 test cycle package.

To achieve realistic measuring results, drive cycle metrics and two further test cycles were added to the 1066 package. To ensure the accurate testing of hybrid vehicles, the AVL iGEM Vehicle is equipped with a unique hybrid package with patented smart, intermittent bag filling procedure. This enables the analysis of large sample volumes. To complement the hybrid application, AVL uses start-stop monitoring (AVL 389) and a Hioki Power Analyzer.

MODEL TECHNOLOGY

The new chassis dynamometer with AVL exhaust emission measurement technology at the NVFEL will support the following testing procedures in accordance with EPA 40 CFR (Code of Federal Regulations) Part 1066: the Greenhouse Gas Regulations and Tier 3 Regulations, as well as the general emission compliance activities and Clean Vehicle Assessment programs for gasoline, diesel, natural-gas-powered and hybrid vehicles. As the EPA also welcomes representatives of various industries and countries on a regular basis, the agency was especially interested in obtaining a test cell that can be regarded as 'best in class' from a functional point of view, which underlines the exceptional position of AVL even further.

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James Williamson,
Regional Business Manager AVL North America



INTERVIEW WITH JAMES WILLIAMSON, REGIONAL BUSINESS MANAGER AVL NORTH AMERICA

What is so special about this project compared to other, similar projects?

"The upgrade project at the EPA cell D329 is primarily focused on the testing of cleanest new vehicles only. This means EPA will only do new vehicle certification for Tier 3. In addition to testing new clean vehicles the system will be capable of HEV, PHEV, and EV testing."

What is the biggest challenge AVL has to overcome?

"In this project it's hard to tell which aspect poses the biggest challenge. Every customer has different requirements. For us, every order is a special task, which we tackle with expertise and experience."

To what extent do AVL's emissions solutions satisfy the customer's needs also in terms of aesthetics?

"The EPA is very satisfied with the flexibility AVL iGEM Vehicle offers. From an aesthetics point of view we designed three layouts for the EPA in our proposal. This attention to detail and our ability to have all the emissions equipment laid out in the optimum arrangement in the control room was key in the decision for selecting AVL." ←



The AVL M.O.V.E. GAS PEMS iS System and AVL M.O.V.E. System Control.

ACHIEVING RDE COMPLIANCE WITH CONSISTENT SOLUTIONS

Statutory emission limit values have brought about a substantial improvement in the air quality across Europe. However, with the shift of the testing environment to the road, conventional approaches fail to achieve 100% reproducibility of exhaust emission tests in real-world driving conditions (RDE). Before compliance verification becomes an insurmountable challenge for OEMs, innovative approaches are urgently needed.

► With the introduction of mandatory RDE (Real Driving Emissions) test procedures as an additional type approval and in-service conformity requirement, OEMs will be facing some major changes: “Development engineers regard leaving their familiar lab environment and stepping out on the road as a serious shift in paradigm as it changes their development focus and approach altogether,” Michael Weißbäck, Deputy Vice President Powertrain Systems Passenger Cars, explained.

And that's not all. Shifting the testing environment to the road also means that the reproducibility of the emission tests is no longer fully ensured. There are far too many factors that require consideration: temperature, altitude, road profile, driving style, which may be anything from moderate to sporty, to mention but a few. In light of these circumstances, conventional development methods require a new approach to emission compliance verification.

FORESIGHT FORMS THE BASIS FOR INNOVATIVE METHODOLOGY

"AVL is certainly a pioneer in this field. The company started to address the issue of RDE many years ago after recognizing its relevance for the future – long before there were any detailed plans for the legislation," Roland Wanker, Global Business Segment Manager, Vehicle Testing Systems said, adding: "AVL's extensive experience in the area of emis-

sion verification in commercial vehicles led to the development of the innovative all-in-one RDE solution AVL M.O.V.E iS. It will allow OEMs to meet the RDE challenges in Europe and worldwide." Apart from that, AVL has brought together a variety of virtual calibration methods and tools in a one-stop solution, enabling emission optimizations in very early development phases. Michael Weißbäck: "Expertise and know-how has additionally been developed for base engine design, aftertreatment and hybridization – all of which is incorporated into a single system."

RIGHTSIZING, NOT DOWNSIZING

As far as engine downsizing is concerned, RDE will slow down this trend. This is because emissions control under different driving conditions have to be brought in line with CO₂ optimization. Michael Weißbäck: "Extreme down-

sizing is counterproductive when it comes to RDE, because emissions verification under real-world driving conditions means that we have to move away from downsizing toward rightsizing. AVL noticed this early on and is now demonstrating how to achieve a better overall package from the tradeoff between fuel consumption and RDE emissions. AVL has already presented some advanced rightsizing solutions in connection with hybrid technologies and electric supercharging," the expert said.

INNOVATIVE DEVELOPMENT APPROACHES

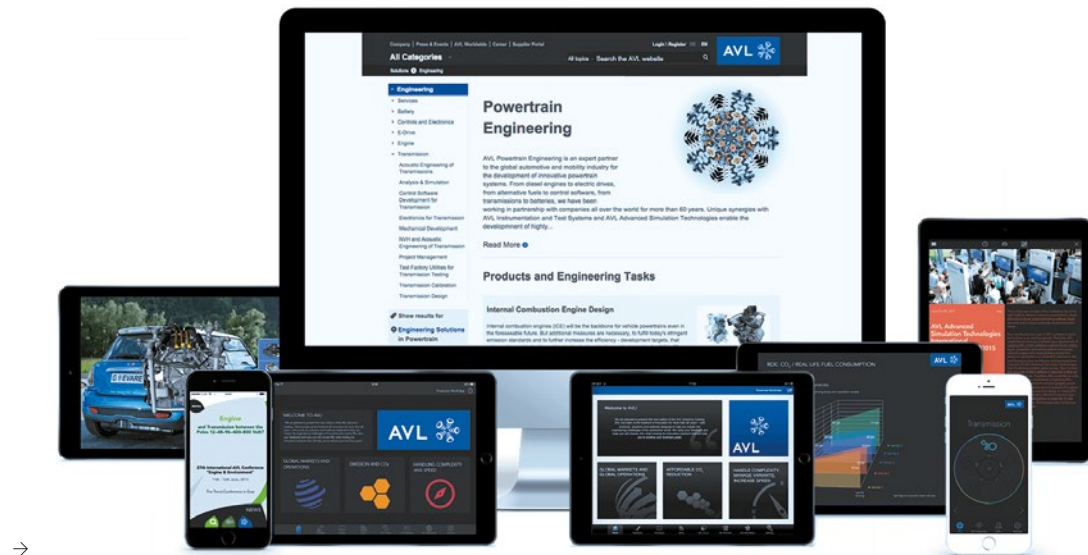
With RDE test reproducibility alone already being an obstacle in itself, the achievement of the RDE targets requires development approaches that cover the whole range of RDE. AVL's solution: The measuring results are brought back to the development environment by using AVL M.O.V.E iS to record data like road profile, climatic conditions, driving style, etc. The recorded results are then re-simulated in the test facility or, more specifically, transferred to the model-based simulation environment. This makes the tests reproducible, and existing simulation models can even be improved. "We've been offering sophisticated RDE technologies for some time now, which were tried out on test vehicles. Careful attention was also paid to the cost aspect. With our concept of rightsizing we were additionally able to show that RDE considerations do not start on the road but much earlier on, with the development of a drive system concept," Roland Wanker concluded. ←



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The AVL M.O.V.E Exhaust Flow Meter (EFM).



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The AVL M.O.V.E EFM Control Box with EFM Tube and Extensions.



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The AVL Digital Ecosystem consists of numerous channels, such as avl.com, the Powertrain World App, the Engine & Environment App and many more.

DIGITAL ECOSYSTEM ENHANCES INTERACTION AND CUSTOMER SATISFACTION

The growing complexity in powertrain development is increasing the need for quicker and more simplified ways to obtain information in the automotive industry. The AVL Digital Ecosystem helps customers achieve their goals faster by combining the latest communication technologies to an interactive platform for efficient knowledge exchange.

► As a leading technology company in the automotive industry, AVL generates massive amounts of data which is available to its customers independent of time and place. To ensure that this knowledge is accessible anywhere in the world at any given time, a platform had to be created that would allow smooth interaction and knowledge exchange. Giv-

en the diversity of technologies, this was obviously no easy task. Nevertheless, AVL harnessed this very diversity in 2014 to create a network of communication channels that works very much like a digital ecosystem and meets all the requirements of a modern communication platform.

GATHERING INFORMATION THROUGH DIGITAL HYPERCONNECTIVITY

AVL has built a digital ecosystem in which customers not only can instantly access the solutions, products and services they desire; they can even directly get in touch with AVL in a fast and efficient manner. All AVL Digital components form



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AVL Solutions Guide
App for tablets.

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a single communication system that enables customers to access the information they need very quickly. This is because the information request usually takes place digitally before a face-to-face conversation is arranged. Utilizing technologies such as Intelligent Search, Semantic Linking and Recommender Engines, the platform makes it even easier for customers to find exactly what they are looking for.

The numerous channels and elements of the AVL Digital Ecosystem include the official avl.com website, the Webby-Award winning AVL Powertrain World App, the Solutions Guide App with all of AVL's services and products, the innovative Conference App and even social media such as Facebook, Twitter, YouTube and LinkedIn. All these digital elements serve as a single platform to ensure the efficient knowledge exchange between AVL and customers, who tend to use a variety of platforms due to differing requirements and needs. Aside from that, the diverse channels and platforms belonging to the Digital Ecosystem are connected to one another via a hyperconnection, which ensures that customers find whatever they want swiftly and reliably without having to search each of the dif-

ferent platforms individually. On top of that, the digital AVL network is constantly advancing and subject to a continuous improvement process through numerous system updates.

USER JOURNEY AND INTELLIGENT SEARCH FEATURES

At the heart of the platform is the official AVL website avl.com. With its intuitive design, it forms the ideal starting point for a User Journey through the innovative world of AVL technology. A smart search algorithm (Intelligent Search) makes exactly those contents accessible which the customer wishes to explore. The website responds to its users' input in real-time and suggests further reading. Another benefit: customers can save their User Journey – i.e. one's own search history – and

effortlessly share it with other users on different channels, such as apps or social media. This makes the search for certain contents, services or products a fully personalized experience.

The impressive figures convey just how successful this system is. While the number of unique users of AVL Digital was at around 500,000 users three years ago and at one million one year later, the figure skyrocketed up to 1.5 million in 2015. But the AVL Digital Ecosystem does not develop its full potential until there is a great demand for information about current issues – for example Real Driving Emissions (RDE). Customers and any others interested in the topic of RDE can instantly learn more through all digital AVL media – anytime, anywhere.

The increasingly complex powertrain development is causing a rise in the need for information, too. To meet these challenges, AVL's Digital Ecosystem will continue to help simplify and speed up the way customers obtain the information they want. This will particularly be the case when, in future, modern interaction assumes new forms – when AVL products and services move even closer together and are even more tightly interlinked with the digital world. ←



→
Exact search results with
Intelligent Search.

NEXT GENERATION SOOT MEASUREMENT



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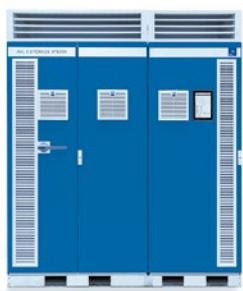
MSS^{plus} – AVL Micro Soot Sensor: the industry standard for the measurement of combustion engine soot emissions.

► With the new MSS^{plus} – AVL Micro Soot Sensor – AVL introduces an innovative enhancement of the industry standard for the measurement of combustion engine soot emissions. It remains the only measurement system in the market that

is able to determine the concentration of soot directly out of the primary measurement value. Moreover, the MSS^{plus} has no cross-sensitivity to other exhaust gas components. The integration of an automated thermophoretic particle loss compensation enables the MSS^{plus} to determine the particle deposition within the sampling system.

Several other improvements and a lower limit of detection allow a wide application area. Furthermore, the MSS^{plus} is easier to use. This makes the measurement system the right choice for your application – with the highest flexibility available for testing on dynamometer and engine testbeds or on board a vehicle for RDE (Real Driving Emission) measurements. ←

EXPLORING NEW E-HORIZONS



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The AVL E-STORAGE BTETM can be used as a battery tester and battery emulator.

► The AVL E-STORAGE BTETM is a combined system that can be used as a battery tester and battery emulator (simulator) to validate and test batteries as well as e-motors and inverters in an early development phase. The system offers a combination of outstanding

dynamic performance with highest measurement and control accuracy.

The AVL E-STORAGE BTETM can precisely emulate a real-world battery and follow a predefined load profile to expose the device under test to real world operating conditions.

Further Benefits:

- Class-leading dynamic performance
- Reduced lifecycle testing time
- Highest measurement and control accuracy
- Reduced required floor space by up to 25% thanks to minimal footprint ←

UNLEASH DATA POWER



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AVL SANTORIN MX 2TM is perfect for the efficient handling of big data.

► In order to provide the stakeholders in the vehicle development process with unrestricted access to all generated data, integrated IT solutions are required at several levels.

AVL SANTORIN MX 2TM is a measurement data platform, based on a standardized ASAM-ODS data base, which allows the administration and uniform interpretation of big data.

The benefits of the software platform include the abilities of centrally and intelligently storing and harmonizing heterogeneous data. In addition, the platform enables both automated server based data processing and analysis in an easy, fast and secure manner.

Further Benefits:

- Significant reduction of time and cost due to standardization and centralization of test data
- Easy navigation and fast search of actual and historical data from various sources ←

AVL Team SUITE™ Success Based on Interplay

THE ADDED VALUE

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POWERTRAIN OPTIMIZATION IN A NETWORKED WORLD

AVL Powertrains with Power Brains. Managing connectivity and complexity.