automotion

Excellence in Automotive Research & Development · IAV Customer Newsletter · 03-2009

IAV Opens its Technical Center North America

New facility brings increased efficiencies

On September 10th, 2009, 18 months after construction had started – IAV celebrated its move to the new IAV Technical Center North America in Northville Township, Michigan with a Grand Opening.

In the morning, government officials, project members, IAV representatives and the press gathered to officially open IAV's Technical Center North America with a ribbon cutting ceremony. While two engine dynamometers were running around the clock on customer projects, two additional cells were made available during the ceremony for presentation to IAV's guests. In the evening, employees of IAV Inc. and IAV GmbH alike celebrated the Grand Opening with customers and long-time company supporters. Representatives of the three local OEMs – Daniel Hancock, Vice President Global Engineering at GM Powertrain; Dan Kapp, Director at Ford Powertrain Research & Advanced; and Robert Lee, Head of Powertrain Engineering at Chrysler Group LLC – offered kind words in acknowledgement of IAV's recent investment and role as an engineering service provider in a drastically changing industry. Demonstration programs, together with technical presentations, served to emphasize the capabilities of IAV's proven dynamometer technology.

The centrally located development center can be easily reached by IAV's customers in southeastern Michigan. Clearly, the state-of-the-art test facility - with its four engine test cells - is the heart of the new Technical Center. The test cells fulfill the same standards as their counterparts in Germany - including, but not limited to, fundamental aspects, such as functionality and measurement quality. One high performance heavy-duty dynamometer accepts large displacement engines with up to 2580 ft.lbs and offers enough space for the aftertreatment systems of tomorrow. Another test cell is dedicated to hybrid electric powertrains, addressing the growing demand for such technology.

The test cells themselves are conditioned using powerful air handling units and circulating air technology. They can be operated unmanned and are equipped with emission test benches from both Horiba and AVL. Engineering tools such as KIS4, VeLoDyn and EasyDoE – all developed in-house by IAV - are available to ensure the completion of customer projects both on time and within budget. To support the engine and prototype set-up, a fully equipped workshop is also located in direct proximity to the test facility.

Despite today's difficult economic situation, IAV is confident that this investment comes at the right time and constitutes an important and necessary milestone for the company's international growth. A broadened US portfolio enables IAV to better support customers locally and provides an excellent platform from which to address the growing demand for global development support.

The coming years will bring with them tremendous engineering challenges, all of which will need to be managed with leaner development budgets. IAV is ready and equipped to tackle these challenges together with our customers.

To all guests and contributors to this most enjoyable event, IAV would like to impart a sincere thank you.

Dr. Gerhard Maas, Kurt Blumenröder, Michael Schubert, Utz-Jens Beister, Ulrich Holthaus, Jeff Sand and David Tyler participated in the ribbon cutting ceremony

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Editorial

Dear Readers,

Although recent government reports indicate that the US economy is slowly recovering, there remains still much to overcome for those working in the automotive sector.

In difficult times like these, investments in new technology are imperative not only to safeguard and grow the business, but also to adjust to changing market requirements.

For these reasons, IAV's recent investment in a new 40,000 square foot technical center has been recognized as a notable milestone and has already served to grow our US business. Located in Northville Township, Michigan, the Technical Center resides in the heartland of the US automotive industry and was officially opened with great celebration on September 10, 2009.

Conversations with our customers regarding the test facility's enhanced capabilities indicate that IAV's modern testing is seen as a welcome addition here in the Detroit area. If you are interested in making use of our test equipment in your own facility, don't miss the article on IAV's KIS 4 knock indication system.

Events of this last quarter have given IAV reason to look forward to next year with reserved optimism. Customer demand is slowly picking up - mainly driven by the need for hybridization, improved fuel economy and lower emissions.

As a result, we end this year in sensible anticipation of the next, aware of the challenges and successes that it will hold for us.

Please read on; you will find more information on these and other topics in our latest issue of automotion. I hope you enjoy this edition and would most welcome the opportunity to have a more in-depth follow-up discussion, perhaps here at our new Technical Center. Best wishes for a happy and safe holiday season.

Utz-Jens Beister
President of IAV Inc.

Knock Unwanted

KIS 4 – the 4th generation of IAV's Knock Indication System now also delivers important heat release values

by Heiko Schilling

KIS 4 is the latest version of IAV's in-house system for analyzing knock in spark-ignition engines. The unit evaluates the in-cylinder pressure signal and, in addition to knock data, also delivers other combustion characteristics for each cylinder and cycle. In many cases, KIS 4 obviates the need for an expensive indication system.

Knock is a serious threat to spark-ignition engines – particularly in higher load ranges where explosion-like, uncontrolled combustion events can cause considerable damage to the engine. "The reason for spontaneous ignition can, for example, be inferior quality fuel," explains Dr. Karsten Röpke, who heads the system development department at IAV, and warns, "Knock produces a sudden rise in pressure and can cause irreparable damage to the cylinder."

Most modern engines are fitted with a diagnostic system that automatically protects them; the knock-recognition system measures the engine's structure-borne sound and the ECU knock controller retards spark timing the moment any undesirable combustion is detected. "The actual measurement signal we use is in-cylinder pressure," Röpke says. "It can be measured directly using a sensor, either through a hole in the cylinder head or with special spark plugs already equipped with a pressure-measurement device."

Although solutions of this type are expensive for use in mass production, in-cylinder pressure sensing plays an important role in development. IAV has been using the KIS system for many years. The fourth generation of this tried and proven measurement and analysis tool has been available since early 2009.

Recording and Evaluating Signals from As Many As Eight Pressure Sensors

"The first version of KIS 4 has eight user-configurable analog inputs with a sampling rate of 400 kHz at a resolution of 16 bits; the voltage range is from - 10 to + 10 V. We can record and evaluate up to eight pressure or knock sensors," Röpke says. "KIS recognizes knock from oscillations at frequencies of between 4 and 25 kHz occurring inside the cylinder; the knock is identified using an efficient filter integrated in a high-speed FPGA chip." KIS 4 can be used in all phases of product development and calibration, whether it be to identify knock during basic calibration or calibrate the production knock control system. The latter demands an increasing amount of work because of two opposing interests: the reduction of consumption and CO_2 emissions pushes the ignition ever closer to the optimum timing; however, this is precisely the range in which most knock occurs. Engineers must find the right balance and develop improved systems for recognizing knock.

KIS 4 Can Also be Used As an Indication System

In addition to peak knock values, KIS 4 also identifies the rate of knock along with the statistical p85 knock value. The new unit can do even more; thanks to the built-in Thermodynamic Real-time Analysis (TRA) card, the latest KIS version can also be used to compute other combustion characteristics for a specific cycle, such as the Mean Fraction Burn (MFB) rate points CA10, CA50 and CA90 (the times at which 10, 50 and 90 percent of the heat has been released in the cylinder). This data is of particular interest to calibration engineers. KIS 4 also delivers the Coefficient Of Variance (COV) value as an indicator of combustion stability.

"These values are normally delivered by indication systems which cost almost three times as much as the new KIS 4," Röpke says. "Our unit can perform nearly every function as that of a regular indication system; it is perfectly adequate for many applications." In the future, this means the developers will be able to perform many of their tasks by using the 25,000 euro KIS 4.

KIS 4 can be readily integrated into the engine test bench automation system to allow fully automated investigations during unmanned operation. KIS 4 is also suitable for use in the vehicle for on-road evaluations. In principle, KIS 4 can also be used for diesel engines, although here it is not knock that is the focus of interest, but rather the additional results of in-cylinder pressure analysis. KIS 4 and the product support thereof is available directly from IAV.

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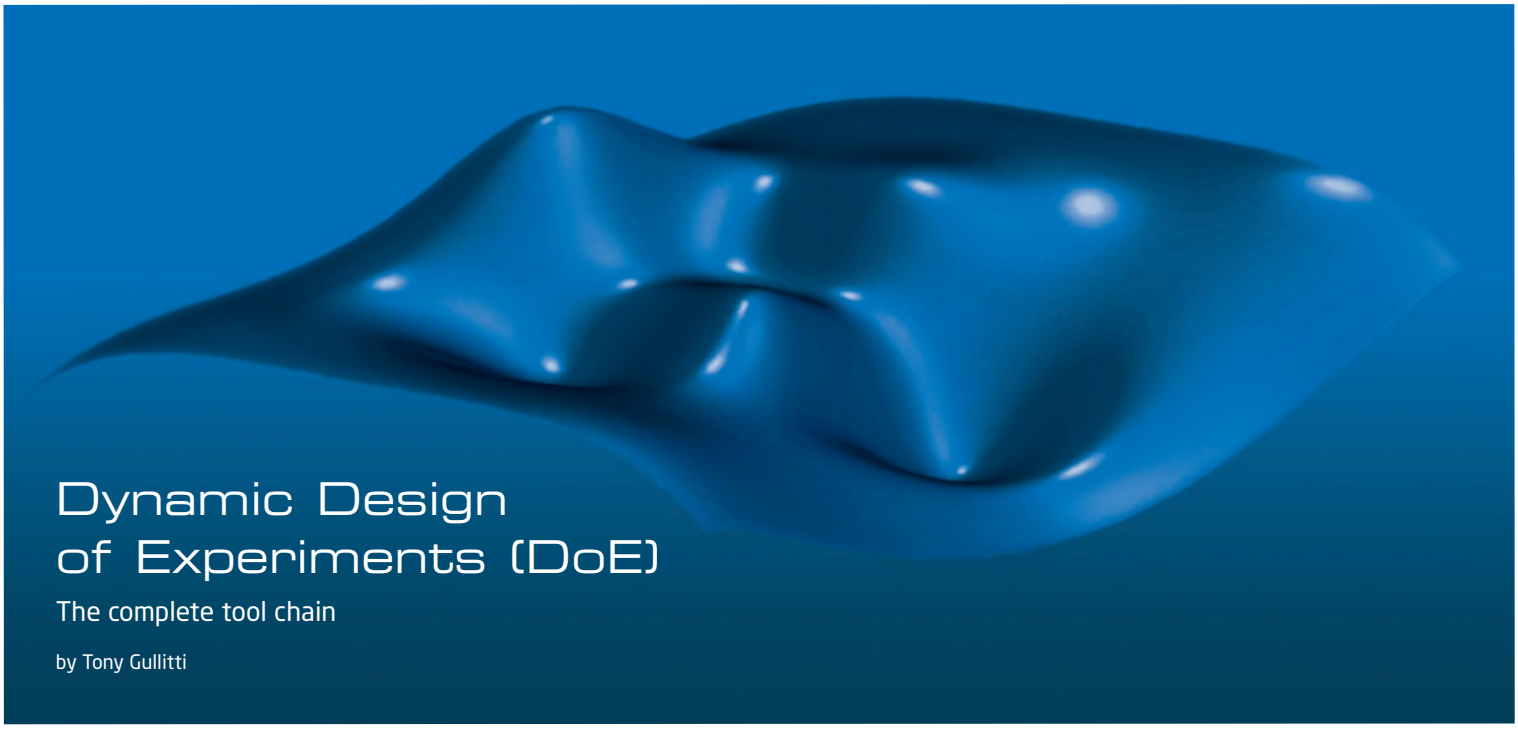
KIS 4 knock indication system



Dynamic Design of Experiments (DoE)

The complete tool chain

by Tony Gullitti

Over the past several years, IAV engineers have successfully applied dynamic modeling techniques to engine calibration. Recent advances in research and development have produced highly sophisticated methods capable of improving the dynamic engine operation phases known to be a major cause of high fuel consumption and emitted pollutants. Tighter legislation and cost pressures now demand the application of both intelligent modeling and optimization techniques, complete with the rapid introduction thereof into the production process.

Dynamic modeling considers the time-varying nature of input and output values in a system. As with steady-state methods, optimization applied to dynamic models can extract multiple solutions from the same set of data. Said ability to model transient engine behavior allows for the systematic method development of transient engine calibration. While parallels do exist between steady-state and dynamic methods, the dynamic approach is more complex and requires an expansion of steady-state methods.

The first area of expansion is the experiment design. As with steady-state methods, the engine operating boundaries need first be determined. There exist many combinations of input parameters which must be measured. The system needs excitation in order to cover the various rates of change in parameters. To guarantee high model quality while keeping measurement costs as low as possible, IAV generates multi-input "chirp", or Amplitude-Modulated Pseudo Random Binary Sequences (APRBS). These fully dynamic experimental designs take into consideration amplitude distribution, frequency distribution, engine operating boundaries and maximum gradients.

Dynamic experiment designs raise the bar at the test bed for measurement complexity and quantity of data produced. Test automation is a requirement with a strong coupling to the engine controller. Depending on the complexity of the calibration task, vehicle simulations using advanced test cell methods may be applied. The simulations can be as simple as the basic duplication of engine speed / load conditions or more complex longitudinal dynamics vehicle models integrated into the dynamometer controller for drive cycle simulation.

Dynamic test results produce a great deal of complex data. The dynamic data can come from many devices on the test cell and can be either time-based or event-based. IAV has developed tools which synchronize data between devices and then re-sample at a consistent data rate. IAV offers services to accompany and decode the measurements, including signal processing and data validation.

The simulation of transient engine behavior is based on non-linear dynamic models. IAV provides methods to create data-driven models, such as Volterra series, neural networks and probabilistic models from measured data. Volterra series models are similar in nature to polynomial regression models. As with steady-state regression equations, a polynomial equation is determined and a set of coefficients established to accommodate the variability of the input and output values over time. Feedback terms may be added, as values of the model output at an earlier time step are used to predict the value at the next time step. Single or multiple time delays may also be considered.

Once the models have been created, optimization of the models can begin. The objective of dynamic optimization is the same as that of steady-state: to minimize emissions and fuel consumption within the constraints of engine roughness and temperature. The result of the optimization, in the dynamic case, produces a time varying trace of optimized input parameters, such as spark advance and injection pulse width, rather than a single value.

Engine optimization based on dynamic models considers the impact of current engine operating values on predicted engine responses. Such dependencies can demand large processing horizons which involve an exceedingly high level of computation. IAV provides methods for overcoming this computational complexity to make optimization possible within a short time. IAV's techniques are based on well-established methods, such as dynamic programming, particle swarm optimization and evolutionary algorithms. As a result, IAV's tools calculate optimum parameter time traces for engine operation, which can be in combination with catalytic converter simulation. The time traces can be used for deriving new control strategies or for improving fuel consumption and emissions.

IAV provides a complete tool chain for steady-state and fully-dynamic engine modeling and optimization. These tools have been applied successfully for:

- rapid measurement at the test cell;
- modeling emissions and optimizing cold-start and driving cycles;
- modeling and optimizing fuel consumption;
- protecting components; and
- virtual engine simulation.

IAV provides support to customers by assisting in integrating these tools into the process chain, supplying documentation and training and offering assistance in developing new fields of application.

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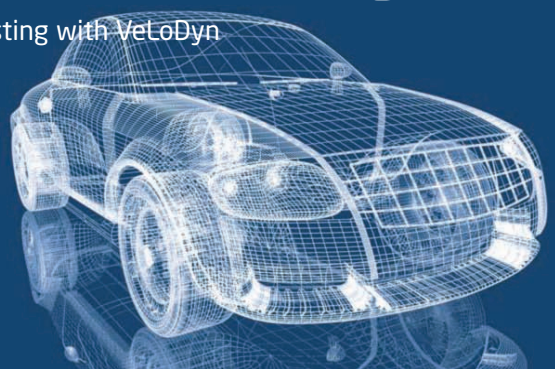
Virtual Vehicle Testing at IAV

Engine-in-the-loop testing with VeLoDyn

by Dr. Michael Traver



Vehicle manufacturers are experiencing increased pressure to execute development programs faster than ever. A precise assessment of the performance of a proposed vehicle and powertrain combination is essential in delivering a final product that consumers will accept and enjoy. Simulation tools are critical for providing this information to engineers early enough to influence the course of a program. IAV's VeLoDyn simulation software is one such tool that has proven useful in this area. Recently, IAV Inc. applied the VeLoDyn simulation tool to explore the potential of hybridizing a heavy-duty diesel pickup truck.

VeLoDyn is typically used to simulate vehicle performance through the desktop simulation of various driveline and chassis components. However, the simulation can also be connected to a dynamometer control computer to evaluate vehicle performance in an "engine-in-the-loop" process. To accomplish this, an independent PC runs a VeLoDyn simulation on any given target vehicle through a programmed vehicle drive cycle, such as the FTP-75; the resulting engine speed and pedal demand values are sent to the dynamometer control computer. The control computer then adjusts the engine speed and torque in response to these inputs and feeds the information back to the simulation. In this way, real engine emissions, fuel economy, NVH and other measurable values can be recorded with a simulated vehicle set-up. It is extremely useful when the need arises to be able to evaluate potential powertrain combinations in a target vehicle without spending the money necessary for a full prototype.

In a recent study, IAV Inc. evaluated the impact of various levels of system-hybridization on the fuel economy of a 6L class diesel engine from a heavy-duty pickup truck; both VeLoDyn and the newly-installed engine dynamometers in the IAV Technical Center North America were used. After validating the vehicle simulation through on-road testing, a baseline measurement was made of the engine on the dynamometer running through the light-duty FTP75 cycle. The cycle was then repeated with a micro-HEV strategy using a start/stop function for the engine. Further tests were run with a mild HEV (25 kW motor and 3kWh battery) and a full HEV (50kW motor and 3kWh battery) layout. The fuel economy improvement for each of the strategies is listed in the table below.

The "engine-in-the-loop" results matched well with the fuel economy numbers originally simulated, although the simulation over-estimated them by an average of 1.2%. The relative benefit of hybridizing such a vehicle is obviously dependent on cost, but these results provide an accurate means of estimating the cost-benefit ratio without significant investment in physical properties.

With future fuel-economy regulations looming on the horizon, IAV's "engine-in-the-loop" simulation approach offers a cost-effective way to evaluate powertrain options for a manufacturer's vehicle portfolio. Knowing the actual impact of development options on emissions and fuel economy substantially lowers the risk for engineering teams seeking to finalize their powertrain programs. Let IAV help guide your company to the right powertrain choice.

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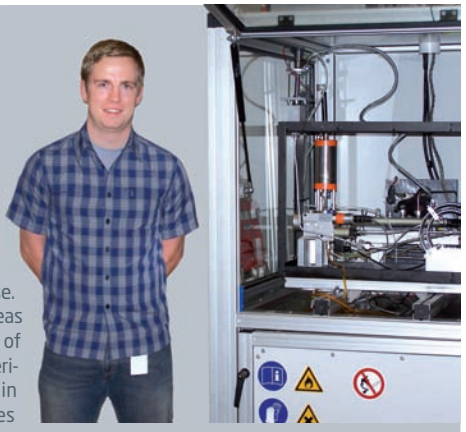
Strategy	Fuel Economy Improvement Over Baseline Engine (%)
Micro HEV	6.7
Mild HEV	11.2
Full HEV	14.3

Employee Spotlight

A German student's experience at IAV

by Christian Albrecht



I first joined IAV Inc. in March 2008 for a six-month internship working with the newly-developed hydraulic test bench and IAV's Injection Analyzer, which arrived from Germany at about the same time. My main responsibilities were to set up the system. I returned to the US in July 2009 to continue my investigations in a similar field and to work on a diploma thesis in mechanical engineering at the University of the German Federal Armed Forces in Munich, Germany.

Though I'm working as a student at IAV, I find my circumstances to be quite unusual; I currently serve in the German Federal Armed Forces while I complete my master's thesis here at IAV. What follows is an abridged account of my experience here at IAV.

Early last year, a fellow soldier from Berlin with some knowledge of IAV happened to tell me about IAV's expansion into a new test facility in the US. I realized that this could be a good opportunity for an engineering internship abroad and, after some phone calls with both IAV GmbH and IAV Inc., my application was accepted.

I had initially imagined that finding a company abroad which agreed to take on a foreign soldier would be the hardest part of the process, but I was proven wrong. Having to coordinate with the many universities, the German Forces and several NATO executives to arrange for the organization of my travel permit, visa-affairs and military supervision in the U.S was a much greater task.

When all was said and done and I was ready to begin my journey to Ann Arbor, IAV's location at the time, I couldn't quiet the apprehension I was feeling. Although I had spent plenty of hours in a military aircraft, it was my first commercial flight, my first time traveling overseas and my first time in an English-speaking country.

My first memory of Detroit involved several random people approaching me in my dress uniform to say "Thank you for serving!" This is surely something that would not happen in Germany.

During my time in the U.S., I have not only had many new experiences and learned a lot working for IAV, but have also explored the country from east to west, visited many cities and made a lot of new friends. I have also begun flight training at the Ann Arbor Airport for a private pilot license. Being able to fly to surrounding areas by myself marks another memory of my time at IAV. It is a unique experience for me to be working in Michigan - more than 500 miles away from my designated military supervisors who are in Reston, Virginia at the German Armed Forces Command.

After my first return to Germany, I finished my university studies and immediately began to plan for my second trip to the U.S. Working with the academic administration and IAV, I selected a topic for my master's thesis.

This year, I have been investigating different measuring methods for high pressure diesel fuel injection systems; the aim is to develop improved injection patterns in multiple injection events using IAV's hydraulic testbench, Injection Analyzer and LMS AMESim simulation software.

So far, the project has extended in several directions and, between my thesis work and Injection Analyzer customer support, I stay very busy. At the moment, I am trying to get my thesis approved for the "THIESEL 2010" conference in Spain about Thermo-and Fluid Dynamic Processes in Diesel Engines.

I will return to Germany at the end of March 2010 to continue my military training, but will feel good about having worked in Ann Arbor/ Northville for nearly 15 months. As my career in the Forces will be limited, I look forward to the idea of working with the IAV team again in the future.

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IAV India Really Takes Off

Offering a wider service portfolio in a new premises

by Heinrich Bruellau, Karl Dokter and Jeremy Goddard

Spring 2009 saw IAV India move into a new, expanded location in Pune, where Indian companies, as well as OEMs from around the world, can now obtain support for their activities on the Indian subcontinent. India is playing an increasingly important role in the global automotive industry as an engineering and production center for inexpensive subcompact cars and commercial vehicles. Numerous OEMs seek to leverage the opportunities offered by the Indian market, and have accordingly set up subsidiaries therein or, alternatively, entered into related cooperation agreements.

Since 2007, IAV has had a subsidiary in Pune - IAV India Pvt. Ltd. in the state of Maharashtra - but in March, IAV staff moved into a new location formally consecrated by a Hindu priest. The official inauguration ceremony took place on May 19, 2009. In addition to numerous customers and guests, the occasion was attended by Germany's Consul General, Walter Stechel, and IAV President and CEO, Kurt Blumenröder.

The 15 Indian members of staff, together with the Managing Director, Heinrich Brüllau, now have a modern infrastructure from which to communicate smoothly with IAV sites around the world. The branch office currently occupies approximately 8600 square feet. Expansion plans allow for the floor space to be extended by the end of 2010 to accommodate the 65 members of staff eventually expected to be working there. By building on the developing base in India, IAV aims to expand its position in emerging markets and help secure its future competitiveness, much like that which was initiated with IAV operations in Brazil and China.

India, a Growth Market

In the near future, India will play an increasingly significant role in the growing segment of inexpensive passenger cars and commercial vehicles. "The truck industry will likely supply the world market from India," explains Karl Dokter, Vice-President of IAV's Consulting4Drive subsidiary and responsible for the "IAV goes India" project. "In the medium term, light-duty commercial vehicles for the European market may very well come in significant volumes from India." This is already becoming a reality in the passenger car segment: Indian manufacturer Tata is supplying its INDICA subcompact car to southern and eastern Europe.

IAV India's business model rests on three pillars. First, IAV supports the local automotive industry in developing new products. "To do this, we need an office on location because, in the field of engineering, Indian partners expect a high proportion of added value at the local level," Dokter says. This is no longer a problem; the new office is equipped with modern CAD workstations, and IAV's Indian staff carry out development work directly for the local market. They are, in turn, supported by experts from Germany, who provide advanced training. "The basic training given to Indian engineers is comparable to that in Germany," Dokter reports. "We have addressed some of the gaps with specialized training, and are providing a very high standard in local project work."

Off-shoring work packages is the second pillar on which IAV's activities are built. "Labor costs in India are well below those in Germany," explains Dokter. "Leveraging cost-effective resources from IAV India makes it possible to generate additional project business for IAV, and this will secure jobs elsewhere in the company."

The third mainstay of IAV's activities is the support given to European OEMs wanting to play an active part in the Indian market. "This also includes training Indian suppliers, for example," Dokter says. Volkswagen has been one of the local customers involved from the very start of the IAV operation in India; staff from IAV provide VW with support in developing the supplier base. The collaboration, which began in 2004 with India's largest vehicle manufacturer, Tata, is being continued, and new OEMs are on the business acquisition list. "IAV's local presence in India has already attracted interesting inquiries from this up-and-coming market," Dokter explains, "IAV India is also expecting to make a strong contribution to moving the IAV Group forward."

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Berlin Drives on Electric Power

Recharging station goes into service at IAV site

by Carsten von Essen, Jason McConnell

Locals are starting to see Berlin as the vehicle fleet testing capital of Germany. Having become used to seeing hydrogen vehicles on the streets, residents and visitors to Berlin are now seeing more and more electric vehicles, predominantly those being fleet tested by BMW and Vattenfall.

The pilot phase of the "MINI E Berlin powered by Vattenfall" - a joint venture between the BMW Group and Vattenfall, one of Europe's leading energy providers - is now underway. Fifty electrically-powered MINI Es have been driving on Berlin's roads since the end of June and, as of July, have been able to "fill up" at IAV's facility in the Charlottenburg area of Berlin.

The electric charging station, which lies just outside the entrance to IAV, went into service on July 1st. This publicly accessible station represents a considerable fraction of the recharging infrastructure being set up for the project by Vattenfall Europe; in total, fifty charging points will be available to the public. Naturally, use of the charging station is not limited to MINI E test vehicles; any and all electric cars are welcomed to benefit. The recharging station provides only "certified green" electricity produced from renewable sources.

"IAV has been working on alternative and electric drives for over 15 years, so a recharging station makes an excellent addition to our operations here," explains Kurt Blumenröder, IAV President and CEO. In the future, Vattenfall and IAV will be working together in the field of electromobility, and both look forward to benefiting from the other's expertise.

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Public Appearances & Publications

January

January 28, 2010
8th International CTI Forum "Exhaust Systems"
Stuttgart, Germany

Paper: "Exhaust Gas Recirculation EGR on SI Engines – Status Quo and Future Aspects"
marc.sens@iav.de

ATZ 1/2010
"Model-Based Algorithm Development at the OEM - Automated from the Idea to the Production ECU"
sven.potrykus@iav.de,
Dr. A. Arenz (VW)

February

February 9 – 11, 2010
EUROFORUM Conference "Electronic Systems in Vehicles"
Munich, Germany

February 10 - 11, 2010
Hybrid Vehicle Technologies Symposium
San Diego, CA

February 24 – 25, 2010
7th Brunswick Symposium "Hybrid-, Electric Vehicles und Energy Management"
Brunswick, Germany

Paper: "Electromobility – Inductive Energy Transfer"
wilfried.nietschke@iav.de

ATZ 2/2010
"Developing Functions Assembly-Line Style"
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lars.rudolf@iav.de

March

March 17 – 18, 2010
VDI Conference "Electomobility – Automotive Industry meets Energy Industry"
Stuttgart, Germany

Paper: "Innovative Charging Concepts"
wilfried.nietschke@iav.de

April

April 29 – 30, 2010
31st International Vienna Engine Symposium
Vienna, Austria

Paper: "Continuous Injection Rate-Shaping for Passenger-Car Diesel Engines – Potential, Limits and Feasibility"
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May

May 26 –27, 2010
SIA – Diesel Engines
Rouen, France

May 31 – June 1, 2010
4th IAV-Conference "Simulation and Testing for Automotive Electronics – From Concept to Series"
Berlin, Germany

MTZ 5/2010
"CO_2 Neutral Particulate Matter Reduction in Diesel Particulate Filter"
michael.frambourg@iav.de

June

June 8 - 9, 2010
4th CTI Symposium & Exhibition, Automotive Transmissions North America
Detroit, MI

June 14 –15, 2010
3rd IAV-Conference "Engine Process Simulation and Supercharging"
Berlin, Germany

June 14 –16, 2010
Emissions 2010 Conference
Ann Arbor, MI

Paper: "The Future is Driven by Structurally Optimized Transmissions"
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mirko.leesch@iav.de,
rico.resch@iav.de

June 17 –18, 2010
2nd Electromobility Congress
Bonn, Germany

June 22 – 23, 2010
VDI-Conference "Transmission in Vehicles 2010"
Friedrichshafen, Germany