For the next decade the Gasoline engine will remain the primary propulsion source for passenger cars. It has achieved significant improvements in terms of energy efficiency while downsizing in combination with direct injection have resulted in significant improvements in CO₂ reduction without sacrifices in terms of “fun-to-drive.” There is further technical solution potential (cf. Fig. 1).

Depending on the vehicle configuration, the upcoming Worldwide harmonized Light vehicles Test Procedures (WLTP) certification values will vary between WLTP low and WLTP high, but on a higher level compared to the NEDC. Significant further fuel consumption reduction can be enabled within the time frame leading up to 2020. Downsizing in combination with downspeeding has put more emphasis on high load operation where further optimization of combustion efficiency is limited due to knocking and preignition effects. Miller cycle, cooled external EGR and VCR represent technologies that have been or will be introduced in the near future in order to improve the efficiency of Gasoline engines at part load as well as during full load operation.
Dear Spectrums readers,

Technical developments to fulfil the demand of mobility have not lost any of their fascination. However, the necessity of reducing fuel consumption and exhaust emissions is undisputed. This is demonstrated e.g. by more than 100 expert presentations and a record number of registrations for this year’s Aachen Colloquium Automobile and Engine Technology.

This edition of Spectrum is dedicated to the continuous improvement of SI and diesel engines for passenger cars and commercial applications. It illustrates clearly how big the optimization potential with regards to fuel savings is. Hybridization offers another level of freedom as our example of the P-REX technology shows. Software development and communication technologies are further important building blocks for the improvement of drive systems and traffic.

We look forward to engaging discussions with you and to supporting your solutions in the fascinating area of mobility.

Sincerely yours

Sincerely yours

Dr. Markus Schwaderlapp
Executive Vice President FEV GmbH

Condensate injection concept offers potential beyond 2020

In search of potential to improve the efficiency of Gasoline combustion even beyond 2020, FEV has developed the condensate injection concept, in which the condensed exhaust gas is fed back into the engine. This offers potential synergies which can be further enabled by exhaust heat recovery. There is also a possible extension of this concept, in which the condensed water from the air conditioning system can be added to a buffer tank from which the condensate is extracted and fed into the engine.

Based upon initial investigations on a TC GDI engine that features PFI injection of the EGR condensate, the concept has been extended in regard to two aspects. Direct injection was considered for the condensate as well as for the Gasoline injection. Moreover the condensation concept was changed to allow utilization of the condensate from the entire exhaust gas stream and not only EGR condensate. This operation principle allows the entire injected condensate to be recycled.

After optimizing the fuel parameters as well as condensate injection, the potential of condensate injection in combination with the Miller cycle and cooled external EGR was evaluated at IMEP = 14.5 bar at n = 2,000 rpm. The engine remained knock limited despite the utilization of both technologies due to the high geometric compression ratio of 13.5.

Using condensate injection via the side injector, MFB 50 decreases linearly with increased water quantity and reaches an optimum of ~ 8° CA ATDC at a wa-
ter/fuel-ratio of 50 percent (cf. Fig. 2). The best fuel consumption is achieved at a water/fuel-ratio of 37 percent (mass fraction) with an indicated fuel consumption reduction of 3.5 percent in addition to the reduction caused by the efficiency improvements that result from the Miller cycle and cooled EGR.

Further fuel consumption reductions

Similar results are achieved if the engine speed is increased from \( n = 2,000 \) rpm to \( n = 3,000 \) rpm at almost constant load. Further fuel consumption reductions can be realized with lean burn operation instead of cooled EGR. In such a case, condensate injection can enable direct fuel consumption reduction via knock mitigation and indirect fuel consumption reduction via NOx, raw emission reductions.

The water/fuel-ratio variation at \( n = 2,000 \) rpm and IMEP = 14.5 bar was also repeated using the central direct injector for water injection and the side direct injector for Gasoline injection (cf. Fig 3). Slightly higher cyclic fluctuations result in poorer MFB 50 phasing without water injection. Fuel consumption is nearly identical. As a consequence of the higher knock restriction, a higher water/fuel-ratio is required for the setup with the side Gasoline injector to achieve optimal combustion phasing. Condensate injection and Miller cycle are sufficient to enable optimal combustion at medium part load up to ~ 10 bar BMEP even with a 13.5:1 compression ratio.

For an engine concept with variable compression ratio, the combination of condensate injection with Miller cycle and cooled EGR will allow a further increase in efficiency at part load, as well, since a higher compression ratio can be used at higher loads.

In further development stages of the Extended Direct Condensate Injection system, material compatibility issues of the water injection system components and other aspects such as freezing protection will be addressed.

Seibel_j@fev.com
CITY-e – Connected Intelligence for Mobility and Society in Europe

Research and development on car-to-car (C2C) and car-to-x (C2X) communication has tremendously increased during the past years. Starting with preliminary studies more than 10 years ago, and subsequent development of early prototypes and demonstrators, some applications are already in use today in major fleet tests. In the future, connected cars will collect valuable data, also considered as “mobile sensors”, such as driving, traffic and environmental conditions. This input can be used for smart mobility applications which, in particular, help to enhance road safety and the use of infrastructure in European urban environments.

Against this background, Denso Automotive and FEV started the CITY-e project in the summer of 2013. Within the initial phase, a development platform was designed to create new and intelligent communication services (iCS) and subsequently verification in fleet tests. Electric vehicles from FEV fleet were used, since they provide extended CAN bus access to car and drive system data. An intelligent connection unit (iCU) analyzes the car and drive system data and provides it via telematics exchange to a private cloud as well as for C2C communication. With this infrastructure it is possible to process vehicle data, in addition to various external data, to support new communication services. Processed information can be used to assist the driver as well as traffic control centers and other authorities, for example, to resolve traffic disruptions.

Upon successful completion of the first project phase, the next phase will address development and testing of new functionalities and solutions, especially with regard to increase road safety.

The CITY-e development platform is available for use by additional external partners, to implement their own intelligent applications and services. This can be done in publicly-sponsored research and development projects, by a small consortium consisting of suppliers and OEMs or in cooperation with IT and telecommunication companies.

Wegner@fev.com
EU Project “Powerful” – A Significant Step in CO₂-Reduction Based on the Highly Efficient 3Cyl TDI®

Engine measures as well as a special exhaust after-treatment systems have been developed to reach CO₂ emissions below 98 g/km in the NEDC and below the EU6 emission limits by a margin of 10 percent.

These impressive results, obtained during performance of the EU project POWERFUL, were realized in a VW Golf Variant test vehicle and were analyzed over the NEDC as well as in more dynamic driving cycles on both a chassis dynamometer as well as on public streets. A Volkswagen AG developed 3-cylinder TDI® engine with a displacement of 1.4 liters was used, which features an optimized high pressure injection pump, a ball bearing turbocharger, steel pistons, combustion control and a decoupled auxiliary belt drive.

Additionally, a homogeneous combustion process (LTC = Low Temperature Combustion) was activated in certain engine operating regions and a special fuel mixture was used. With these measures, a CO₂ emission of 95 g/km and fulfillment of the emission targets was achieved. The calibration was also optimized using a target-orientated calibration process.

Efficient combination

The Institute for Combustion Engines at the RWTH Aachen University (VKA) and FEV developed an innovative aftertreatment system to support this project, that consists of a conventional close-coupled DOC/DPF combination, an exhaust gas reformer, a Lean NOx Trap (LNT) in an underfloor position and an SCR catalyst downstream of the LNT. The SCR catalyst stores NH₃ generated during the regeneration of the LNT and, thus, reduces the remaining nitrogen oxides (NOₓ), downstream of the LNT.

A bypass is included in the system as an additional special feature that can be activated by exhaust flaps and pass the exhaust flow around the LNT and directly to the SCR catalyst. This happens when the LNT needs to be regenerated. The required rich gas mixture was generated by a reformer in the POWERFUL project, which is simulated by a gas bottle in the test vehicle. Fig. 4 shows how the EU6 NOₓ emission limits can be clearly undercut in NEDC and WLTC. In random cycles, representing real driving conditions and carried out with soft, normal and aggressive driving styles, a clear correlation between NOₓ and CO₂ emissions is visible. With application of a moderate driving style, the CO₂ emissions are even lower as in NEDC, combined with safe NOₓ compliance. With a more dynamic driving style, fuel consumption increases significantly and NOₓ emissions exceed the limits.

The research that lead to these results was made possible through funding from the European Union 7th Framework Program [FP7/2007-2011] under grant agreement No. 234032. The authors are grateful for the funding provided by the EU in the “Powerful” research project as well as to all of the people who contributed to the study that was conducted in the author’s R&D laboratories.

Holderbaum@fev.com
The automotive powertrain has become steadily more complex over the past decades. Demanding emission and CO₂ legislation calls for more advanced control strategies while new safety and comfort functions are causing a higher nesting of functionalities. Additionally, an increasing number of product variants must be considered. As a result, software is becoming a core innovation and cost factor.

As a countermeasure to combat this complexity, FEV has developed a new software development process. This process and the accompanying tool chain is called PERSIST (Powertrain control architecture Enabling Reusable Software development for Intelligent System Tailoring). It can be applied at an early stage of function development.

Solution approach

The solution involves simplification of the number of calibration parameters and interfaces by applying model-based control and implementation of the functions within a software architecture that reflects the control strategy, allowing for standardization and leveraging of the reuse potential. This joint strategy reduces development time and cost by speeding-up software specification and implementation through reuse and reduced calibration effort.

Development framework and software architecture

The framework requirements can be summarized into three aspects:

- Design for software quality
- Application from early prototyping phase to volume production
- Continuous quality assessment

Diverse investigations, conducted by FEV, show that architecture has a severe influence on software quality. Early design decisions can either guarantee code which satisfies various needs or complicates later working steps including implementation, integration and testing significantly.

Shorter development cycles urge software developers to react quickly to changes or updates of requirement definitions. As a consequence, quality must be checked continuously using agile development principles. Late detection of quality defects (e.g. shortly before development milestones) are avoided since the verification and validation status is continuously updated.

Fig. 5 shows the resulting development approach that incorporates these requirements. It is based on the daily performance of automated implementation, verification and validation and release activities for a defined software function library that follows a consistent architecture. Changing requirements can be taken into account quickly and new release candidates can be generated that are available for field validation. Suitable agile methods and long-term architecture development
are combined and form the basis for efficient application of automated development support.

**Parallelized development of control units**

The reference architecture is AUTOSAR. The System Architecture is derived from system requirements by grouping functionalities (logical architecture) and defining use cases and customer acceptance tests. Functionalities are assigned to mechanical and electronic system components (technical architecture). Once this step is complete, the development of different control units can be parallelized to decrease the development time.

Software Architecture development involves Software Component (SW-C) definition and the assignment of System Requirements to them. To profit from automated accessibility of all functions Continuous Integration (CI) is also used for automated quality assessment in addition to performing code generation, build and, for example, documentation tasks.

The CI principles are adapted in accordance with the development framework requirements: All developers contribute work products on a common data repository. An integration server polls the work products regularly and performs a build while also processing the software model verification and validation (V&V).

This includes diverse aspects of quality checks such as modeling guidelines, metrics or unit tests.

**Model-based control for simplified calibration**

Over the last ten years FEV has developed model based control concepts for both air and fuel path control for demonstrator and series usage. The main targets of these developments were to enable strongly reduced calibration effort especially reducing the effort for ambient corrections, which are in most cases compensated by the physical based structures. At the same time these physical based functions also lead to significant increase of overall system robustness and to redundancies in certain information (such as certain temperatures and pressures, but also emissions like NOx) which can then be used for increased emission robustness, model adjustment or reduction of sensor content. All these control concepts are transferred into the PERSIST framework for easy reuse and better maintainability.

As one example Fig. 6 shows the architecture of the emission based air path control concept for Diesel engines. This concept controls the EGR path(s) based on a target engine-out NOx emission level.

Richenhagen@fev.com, Schnorbus@fev.com, Orth@fev.com

---

**Fig. 6: Emission based EGR control concept**
California’s LEV III is the current OEM target for future motor vehicle emission regulations for Diesel vehicles. The formidable challenge represented by these limitations will likely be met through combustion process improvements, and hence, reduced raw emissions. But this will, likely not be enough. Improvements in exhaust gas aftertreatment efficiency and the use of enhanced control logic will also become necessary.

The requirements of Diesel vehicle on-board diagnostic systems (OBD) are becoming more challenging, as well. The currently employed monitoring strategies can no longer guarantee reliable detection of partially failed systems. Monitoring of aftertreatment components will become particularly complex with higher system efficiencies, since the margin between a part at the tolerance limit and a properly functioning component will be much smaller. With this in mind, OBD can impact the tailored selection of future exhaust aftertreatment systems.
Challenges for OBD strategies

To fulfill the LEV III thresholds, combined NO\textsubscript{x} aftertreatment systems (for example, NO\textsubscript{x} storage catalysts (NSC) plus an SCR system) represent an attractive and comprehensive approach. The split of NO\textsubscript{x} conversion, in general, represents a noticeable benefit with regard to diagnosis of the aftertreatment system, since the component efficiency loss that must be detected is decisively lower, even for high overall NO\textsubscript{x} reduction.

However, the increasing complexity of aftertreatment systems requires an appropriate adaption of the existing monitoring strategies as well. For instance, low NO\textsubscript{x} concentrations downstream of the NSC represent a risk for robust and frequent SCR monitoring due to limited accuracy of the NO\textsubscript{x} sensors.

The on-board diagnostic system must ensure ongoing improvement in the monitoring concepts in order to support compliance with future emission legislations. Therefore, FEV GmbH is developing potential OBD diagnosis strategies for various innovative aftertreatment systems with regard to regulation compliance and robustness, optimally using existing sensor concepts. Due to increased interaction, enhanced exchange of information between the monitoring functions as well as the application of active strategies are needed to design an intelligent and holistic diagnosis system for the aftertreatment system. Monitoring for increased component efficiencies must not only be guaranteed by advanced software based approaches. In addition, this goal must be realized by minimizing the number of sensors and adaptation of a cost-oriented calibration effort.

Mueller_v@vka.rwth-aachen.de
Smart Plug-In Hybrid Concept for Small and Mid-Size Vehicles

Powertrain electrification is a key element in strategies to reduce fuel consumption and CO₂ emissions and, therefore, a major driver of new technologies in the global automotive industry. FEV has developed a compact and low cost hybrid concept called P-REX, which allows extended usage of electric driving in a range of vehicles from sub-compact up to mid-size. The compact but powerful concept is capable of providing two electric drive modes, two parallel modes and two CVT modes with only one electric motor and the system can also be used as a launch device as well as to start the combustion engine without the need for an additional starter.

The P-REX Plug-In Hybrid concept

The P-Rex transmission consists of two planetary gear sets (PGS1 & PGS2), two clutches (C1 & C2), one brake (B1) and a one-way-clutch (OWC). The single electric motor (EM) is concentrically positioned around the gear set. The first planetary gear set PGS1 acts together with a brake (B1) and a clutch (C1) as a two-speed transmission for the combustion engine. The second planetary gear set (PGS2) acts as a power-split device with the lockup-clutch (C2). A smooth transition between the two electric drive modes is realized by a one-way clutch that is installed in the gear set. This one-way clutch enables the transition by actuating a shift of one clutch against the OWC, thus allowing optimum shift quality.

Low costs, high performance

To realize a transmission with lowest possible costs, all of the clutches and the brake use the same disc size and both single pinion type planetary gear sets are identical with equal ratios. Six different operating modes are used to generate a high degree of flexibility: Electric driving is accomplished with two different speeds, allowing the electric motor to be operated at very efficient operating points. For highway driving, two parallel modes can be used over different speed ranges and two CVT modes allow launching of the vehicle as well as to start the combustion engine without the need for an additional starter.
Vehicle in hybrid mode without slipping launch devices. During vehicle launch, an EM Boost can be performed even with an empty hybrid battery.

Determination of hybrid strategy and influence of fuel consumption

The high degree of flexibility of the P-REX transmission with two parallel-, two CVT- and two E-Drive modes requires careful layout of the shift-strategy to optimize fuel consumption. This was realized by a detailed vehicle simulation based analysis. The simulation model that was used incorporates a 4 cylinder, 1.6 L SI engine and an electric machine with a peak power of 82.5 kW and a maximum speed of 7,000 rpm in a standard small size vehicle. For simplification, the inverter efficiency was set to constantly 97 percent.

The project results indicate a total system energy consumption in each combined operating mode. In this mode, the E-Motor can be charging or boosting, dependent upon the system power required. With the resulting data, the optimum operating mode for each vehicle driving condition can be determined.

To determine the parameters, which define the strategy for shifting from electric driving to hybrid driving and vice versa, FEV uses its TOPexpert PROcal tool-set in combination with the vehicle simulation. Based on a set of boundary conditions for each parameter, PROcal defines a (Design of Experiments based) model and validation points using design of experiment. At these points, the vehicle simulation then calculates the fuel consumption in one selected driving cycle – NEDC in our case.

With these limits the vehicle achieves a minimum fuel consumption of 4.9 L/100km in the charge sustaining mode in the NEDC. The same vehicle with a conventional powertrain and manual transmission has a NEDC fuel consumption of 6.7 L/100km. Therefore, a reduction in fuel consumption of almost 27 percent has been achieved with the P-REX concept.

The FEV development team is confident that P-REX will add substantial benefit to the process of development and integration of hybrid powertrains into a range from sub-compact up to mid-sized vehicles. A gear set very similar to the P-REX concept has already been realized and tested in a demonstrator vehicle with very promising results.

Kirschstein@fev.com, Ogrzewalla@fev.com, Janssen_p@fev.com, Auweiler@fev.com

Fig. 11: Energy flow in different hybrid modes of the P-REX transmission

Fig. 12: Parameter optimization by FEV TOPexpert PROcal
The New Yanmar TNV Engine Series for Future Off-Road Machinery

Close to customer demands: Yanmar, with strong FEV support has developed the new TNV series engine that offers a power output range of 19 to 56 kW. As a result of the development cooperation, the TNV is a powerful, quiet, and highly durable engine series with improved fuel consumption and it complies with strict Tier 4 emission regulations. Yanmar’s advanced combustion technology, featuring a common rail injection system and cooled exhaust gas recirculation (EGR) is combined with model-based control strategies that are leveraged to achieve excellent engine performance under all operating conditions. In addition, an exhaust aftertreatment system that includes a Diesel particulate filter (DPF) has been adopted for cleaner exhaust gas emission, making it a truly “green” engine.

3-step regeneration strategy

The unique model allows the amount of PM accumulated in the soot filter to be precisely estimated for a better regeneration schedule and the integrated engine and aftertreatment management system helps to achieve reliable DPF regeneration for all relevant off-road machinery application operating cycles and boundary conditions. To achieve these goals, a unique 3-step regeneration strategy without changing engine operating feeling is used:

- **“Assist regeneration”:** The first step of DPF regeneration with intermediate temperature is initiated when the amount of PM reaches a predefined limit.
- **“Reset regeneration”:** The second step of DPF regeneration with higher exhaust temperature is activated when a pre-defined amount of operating time is reached.
- **“Unscheduled Stationary regeneration”:** The third step will be requested for safety reasons, in the case that “assist regeneration” and “reset regeneration” cannot be successfully achieved and PM loading exceeds a pre-defined limit.

Wiartalla@fev.com

Fig. 13: New TNV engine technology features

The engine management system employs Yanmar’s unique software to assure best engine performance by automatically adjusting engine operating parameters. The EGR rate is controlled on the basis of physical models without using an air mass flow sensor, thus enabling compensation of environmental impacts (such as altitude), varying backpressure (due to DPF loading) or intake piping geometry. This leads to benefits for real-world operation as well as reduced calibration effort.

Safe compliance with Tier 4 emission limits

Compared to previous EPA Tier 3 engines, the engine family’s steady-state NOx+NMHC emissions are significantly reduced by using common rail technology and cooled EGR. PM emissions are drastically reduced by the DPF and low emissions during transient operation are further ensured by the engine control software. As a result, the Tier 4 emission limits can be safely achieved in both steady-state (C1) and transient (NRTC) test cycles as well as the not-to-exceed (NTE) engine map area.
Integrated Layout of the Friction Reduced Piston Group

To improve fuel economy and performance in combustion engines, optimization of the FMEP level can be very important. Since up to 30 percent of the engine FMEP is related to the piston group, this area of the motor offers a high potential for optimization. During the development process, the basis for a friction-optimized engine must be already defined at the concept phase. For this reason, the combination of appropriate development tools with respect to both testing and simulation is one of the most efficient ways to realize a friction-optimized engine.

Powerful simulation tool

FEV offers advanced tools for both testing (PIFFO-system) and simulation of the piston group friction. FEV’s „Virtual Engine“ includes an MBS simulation tool that utilizes a full 3D model of the piston group components. This model incorporates 3D flexibility of the rings, a gas blow-by model, a 3D contact model for the piston ring in the groove, a 3D ring-liner contact model that includes hydrodynamic as well as a dry contact components, a model for the oil film on the liner, and a wear model for the liner and rings. Detailed modeling of the piston group is not a stand-alone functionality but a model refinement of the MBS engine model.

Validated prediction and analysis

The simulation model allows validated predictions of the ring friction and the ring dynamics in the groove. The contributions of the piston skirt and rings to the total friction force can be individually resolved and can be separated into hydrodynamic- and a dry-friction components for use in further investigations.

Trend data from the measured signals can be reproduced with minimal effort associated with fine-tuning of the input parameters. Present simulation results suggest that the influence of the axial ring transition does not significantly affect friction. The current 3D MBS model, which features a typical simulation time of about one hour per engine cycle, therefore, represents a particular benefit with regard to layout and optimization of the piston group for optimized friction behavior.

Voncken@fev.com

Fig. 15: Piston group friction force over crank angle over at full load (upper graph: 1,000 rpm, lower graph: 2,000 rpm)

Fig. 16: Axial displacement of the top compression ring for two pressure load cases at 2,000 rpm at three positions (A, B, C) over the ring circumference
New Single-Cylinder Large Bore Engine Test Cell at FEV

FEV has expanded its range of large bore engine development products: At our test facility on the Neuenhofstrasse in Aachen, Germany, a single-cylinder engine in the now-familiar FEV-SCE engine family with an engine displacement of 17 liters and a maximum output of 620 kW has been put into operation (Fig.17). The medium speed engine from the LB 20-40 series has a bore of 260 mm and a stroke of 320 mm and is initially configured as a diesel engine. FEV also plans to run the engine on gas or heavy fuel oil in forthcoming development projects.

Test cell set-up

In order to enable the new single-cylinder test cell, all of the test cells peripherals were redesigned (Fig. 19). This enabled operation of the installed, three-phase, asynchronous machine with a single-cylinder motor at an output of over 1,200 kW. The single-cylinder motor is coupled to the asynchronous machine by means of an elastic coupling. Both components are mounted on a common sprung base. The two separate oil circuits are supplied with pre-heated, filtered oil from two independent oil conditioning systems that are used for mass balancing and for crankshaft and camshaft bearings, as well as for the valve train.

An uninterrupted power supply from a battery ensures that the oil supply to the engine does not come to a stop during the discharge phase in the event of a power outage. The installed fresh air compressor system enables manifold pressures of up to eight bar to be reached. In addition, the FEV Test Systems media conditioners “CoolCon”, “FuelCon” and “FuelRate” have been implemented. They enable the engine to be operated under very tightly controlled operating conditions in terms of cooling, fuel supply, and accurate and continuous measurement of fuel mass flow.

Table 1: Specifications of Single Cylinder Large Bore Engine

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>LB20-40</th>
<th>Current Engine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>min.</td>
<td>max.</td>
<td></td>
</tr>
<tr>
<td>Bore</td>
<td>mm</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>Stroke</td>
<td>mm</td>
<td>280</td>
<td>340</td>
</tr>
<tr>
<td>Displacement</td>
<td>L</td>
<td>9</td>
<td>17</td>
</tr>
<tr>
<td>Nom. engine speed</td>
<td>rpm</td>
<td>1,200</td>
<td>1,100</td>
</tr>
<tr>
<td>Nom. cylinder output</td>
<td>kW</td>
<td>175</td>
<td>620</td>
</tr>
<tr>
<td>Piston speed</td>
<td>m/s</td>
<td>11,2</td>
<td>13,8</td>
</tr>
<tr>
<td>BMEP</td>
<td>bar</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Max. firing pressure</td>
<td>bar</td>
<td>300</td>
<td></td>
</tr>
</tbody>
</table>

This unique test cell, allows FEV to offer its customers a needed, additional service. The availability of a test cell with a medium speed single-cylinder research engine installed enables a considerable reduction in the cost of developing combustion processes and mechanical systems for such large bore engines. But the benefits are not only measured in currency; this benefit also applies to achieving significant reductions in development time. The ability to realistically reproduce combustion boundary conditions such as combustion geometry, gas exchange and fuel injection not only enables a reduction in the cost of conducting testing, but the cost of parts, operating costs and procurement times can all be reduced significantly, as well. The engine is also available for functional tests as well for testing thermal and mechanical loads and for endurance testing.

Fig. 17: FEV Single Cylinder Large Bore Engine, LB 20-40
Modular tool for a variety of engine configurations

Because of the modular design of the FEV single-cylinder engine, it is easy to reproduce different engine configurations. Customized engine designs and strokes can be achieved by adapting a small number of interchangeable components such as liner carrier and crankshaft. Customer-specific components – such as cylinder units with cylinder head and liner, connecting rod and piston – can also be adapted within the single cylinder engine. The FEV single-cylinder large bore engine is a robust and flexible development tool that also meets future needs such as attainment of a maximum firing pressure of 300 bar. Test bench and engine will be available to the customers for development programs on existing and new large engines, operating with Diesel, gas or heavy oil.

Heuser_p@fev.com
Expansion of the FEV Durability Test Center in Brehna (Leipzig, Germany)

In the second expansion step at the FEV Durability Test Center (DLP) in Brehna in early July, Professor Stefan Pischinger, President and CEO of the FEV Group, launched the groundbreaking ceremony together with the State Secretary at the Ministry of Science and Economics in Saxony-Anhalt, Dr. Tamara Zieschang.

In the first expansion step, the total investment for the test center already reached 50 million euro. With the second expansion which includes six new engine test benches, a total of 75 million euro – including technical upgrades – will have been invested since 2007. As a result of this, FEV DLP is now one of the leading facilities worldwide.

“In addition to infrastructural advantages such as motorways and an airport, the automotive region of Leipzig-Halle offers easy access to specialists that are necessary for qualified durability tests of engines and powertrains”, stated Professor Dr. Stefan Pischinger, while explaining the advantages of the FEV facility. In return, the automotive region of Saxony-Anhalt will profit from the planned expansion as well. Driven by the continuous growth of the durability test center, FEV will offer 35 new permanent posts for qualified personnel and engineers.

Paulsen@fev.com