SAE International™ The pan-European magazine of SAE International May/June 2011

ad

automotivedesign.eu.com

Variable compression ratio reborn

- CFD combustion analysis
- Lighting the way
- Exhaust materials
- SAE Review

WITHOUT DUAL CLUTCH TRANSMISSION TECHNOLOGY, YOU'RE JUST GETTING LEFT BEHIND.

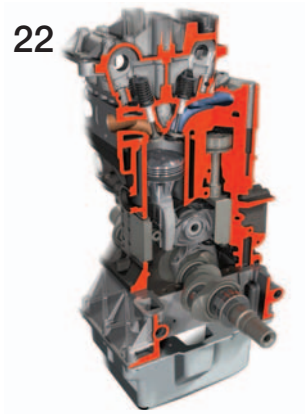
Maybe it's the fact that in the time you read this, a Dual Clutch Transmission could switch gears 40,000 times. Perhaps it's the fact that DCTs appeal to more buyers by combining impressive fuel-economy, the smooth ride of an automatic and the speed of a manual. It could be the fact that leading clutch suppliers estimate they'll quadruple DCT sales by 2014. Or maybe it's the fact that by 2015, 10% of all passenger cars will have them.

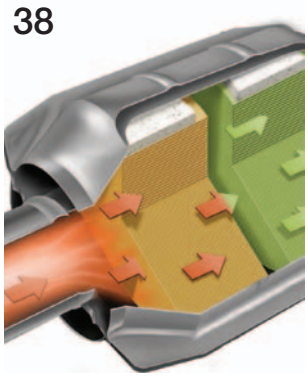
DCTFACTS.COM gives you endless reasons to believe that DCTs are the future generation of transmissions. And the more you know about them, the further ahead you'll get.

DCTFACTS.COM

Lubrizol

Contents





Invented for life is our mission. We develop products and systems that respond today to the global problems of the future. That's why many of the 15 patents Bosch registers every day contribute to progress in renewable energies, emission reduction and fuel economy. Doing our share for a better future. **www.bosch.com**

BOSCH
Invented for life

Editor in Chief: **Ian Adcock**
iadcock@automotivedesigneu.com
Web Editor: **John Challen**
jchallen@automotivedesign.eu.com
Sub Editor: **Brian Wall**
bwall@findlay.co.uk
Editorial Director: **Kevin Jost**, SAE International.
kjost@sae.org
Contributing Editors: **Steven Ashley, Ryan Borroff, Lindsay Brooke, Kami Bucholz, William Diem, Andrew English, Mark Fletcher, Paul Horrell, Keith Howard, John Kendall, Tony Lewin, Bruce Morey, Lou Reade**
Art Editors: **Martin Cherry, Neil Young**
Illustrator: **Phil Holmes**
Production Manager: **Nicki Mckenna**
nmckenna@findlay.co.uk
Publisher: **Ed Tranter**
etranter@automotivedesign.eu.com
Circulation Manager: **Chris Jones**
cjones@findlay.co.uk

Advertisement Sales
Europe/UK
Gordon Herriot
International Sales Manager
gherriot@automotivedesign.eu.com
USA
Print Advertising Coordinator:
Linda Risch
risch@sae.org
Tel: 001 724-772-4039
Marcie Hineman
hineman@sae.org
Germany
Sven Anacker, Ralf Gerbracht
mail@InterMediaPartners.de
Tel: +49.202.27169.17 Fax: +49.202.27169.20
Japan
Shigenori Nagatomo
Akutagawa Bldg, 7-7 Nihonbashi Kabutocho
Chuo-ku, Tokyo 103-0026 JAPAN
Tel: +81.3.3661.6138
Fax: +81.3.3661.6139
nagatomo-pbi@gol.com

Automotive Design
Tel: 00 44 (0)1322 221144
Fax: 00 44 (0)1322 221188
www.automotivedesign.eu.com
ad@automotivedesign.eu.com

ISSN 2043-0299
Published: January, March, May, July, September and November by
AD Media Europe
Hawley Mill, Hawley Road, Dartford, Kent, DA2 7TJ

Annual subscription (6 issues per year) for readers in the UK is £45, overseas is £66 and airmail is £86.

Origination: **CTT**, Walthamstow, London E17 6BU.
Printed in England by
Warners Midland plc

Moving on? If you change jobs or your company moves, please contact circulation@findlay.co.uk to continue receiving your copy of Automotive Design.

After the bad.... comes the good

Log on to any respected automotive industry news website and you will be confronted with an array of good news headlines: CIE Automotive, Tower, TRW, Meritor, Lear, A&AM, Federal-Mogul, Johnson Controls, Denso, BorgWarner, all reporting better-than-forecast sales and profits in the first quarter of the year.

And it isn't only the beleagured supply chain that has had something to cheer about: Fiat, Ford, Hyundai, Chrysler, Daimler, BMW, Skoda, GM, Volvo, they've all announced boosts to their first quarter's earnings.

There was more good news on the manufacturing front as well and I make no apologies for headlining Tata's announcement of a €5.7bn investment programme in Jaguar and Land Rover over the next five years to match the quality of Audi, BMW and Mercedes-Benz, as well as bringing in a raft of new products that will widen both brands' portfolios. This is over and above the €861m it has already pledged for a new engine production plant in the UK.

This is a big boost for UKplc and for the European supply chain as a whole, as it helps secure jobs and wider investment.

Ally that to PSA Peugeot Citroën's plans to invest €350m over three years at its Valenciennes plant – GM confirming a third production facility for the Opel/Vauxhall Astra, as well as extending its range to include a premium product and a small electric vehicle; and BMW setting its sights on global manufacture, with the possibility of production in Brazil, Russia, India, South Korea and Turkey – and there's a real sense in the industry that it has now come through the worst and survived.

Elsewhere in this issue, you will read about innovative computational fluid dynamics (CFD) that predicts the combustion process, and the re-emergence of variable compression ratio engines and laser spark plugs. That's the great thing about the motor industry: it might get battered and bruised, but it always comes back stronger and more innovative than ever before.

Without wishing to tempt fate, the future looks as exciting as it ever has done for all of us who are involved in the motor industry.

Ian Adcock, Editor in Chief

Laser beams in on supremacy of spark plug

Whoever you credit with inventing the spark plug – Edmond Berger, Sir Oliver Lodge or Étienne Lenoir – it has been an essential component of the gasoline internal combustion engine for over a century, since Robert Bosch introduced the first practicable example in 1902. But recent developments in the field of laser ignition suggest that the spark plug's long hegemony may soon be challenged.

Laser ignition is not new. It was first described as long ago as 1978, but then, and for the subsequent two decades or so, it was restricted to the research laboratory. Sufficiently powerful lasers were just too large and too costly for laser ignition to be considered a viable alternative to conventional ignition. By early in the new millennium, though, laser technology had advanced sufficiently for researchers to begin installing laser ignition systems on large, fixed IC engines, the high cost being justified principally by significant fuel economy gains and the consequent reduction in CO_2 emissions.

But laser ignition can also deliver other benefits. An ability to ignite leaner mixtures than a spark plug allows for the reduction of NOx emissions, combustion is more stable, idle speed can be lowered and freedom from the effects of electrode erosion reduces maintenance requirements. When, as part of the advanced reciprocating engine systems (ARES) research project in the US, tests of laser ignition were conducted on a Bombardier BSCRE-04 large capacity single-cylinder natural gas fuelled research engine, results included a 70% reduction in engine-out NOx for the same engine efficiency or a 3% increase in brake thermal efficiency for given NOx output.

Combustion stability was also improved, compared to capacitor discharge ignition. Other engine research and development programmes within ARES and California's ARICE (advanced reciprocating internal combustion engine) initiative, also conducted on large stationary engines, have reported fuel efficiency increases of greater than 45% and NOx-emission reductions of more than an order of magnitude, when compared to ignition by standard spark-gap spark plugs.

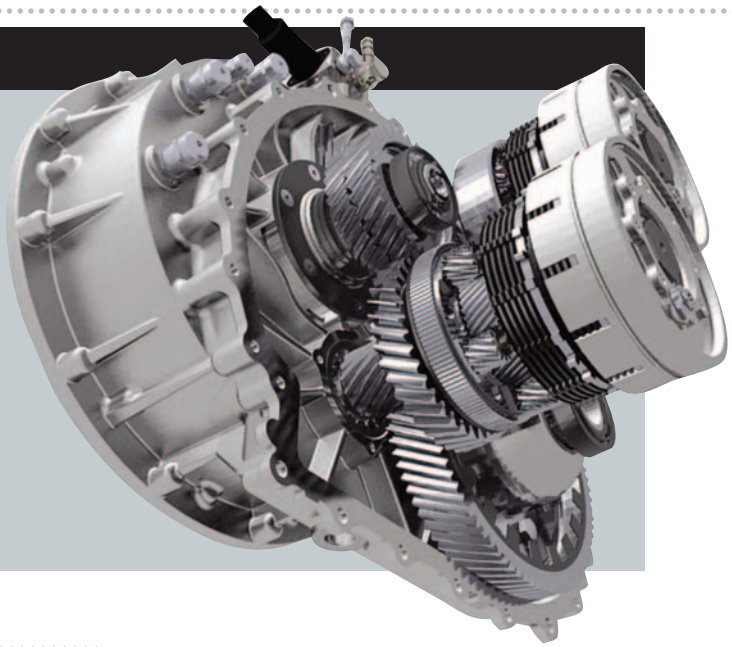
Four laser ignition mechanisms have been identified: non-resonant breakdown ignition, resonant breakdown ignition, thermal ignition and photochemical ignition. The first mechanism, which is similar to that of a conventional spark plug, is the most widely used and studied.

Laser ignition's efficiency advantage arises principally because the point of ignition can be chosen more flexibly than with a spark plug, allowing ignition to be initiated away from the 'cold' cylinder wall; and because the undesirable shielding and thermal quenching action of a spark plug's earth electrode are avoided. As a result, the flame kernel expands considerably faster, as revealed by Schlieren photography, and in-cylinder pressure monitoring shows significantly shortened combustion time. Even better results can be achieved, if multiple points of ignition are created, using separate laser beams focused at sufficiently spaced points within the mixture. A sapphire window at the

FEV hybrid transmission

FEV's EDE/Hybrid/PGS transmission is an extreme downsized parallel hybrid powertrain, featuring a 20 kW/140 Nm electric motor and a 74 kW/130 Nm DI gasoline engine, coupled with a newly developed planetary gearset automatic transmission. The seven-speed, compact, electrically assisted hybrid automatic transmission has been designed for transverse (FWD) applications. This concept can deliver pure electric driving, as well as boost and regeneration modes.

It also displayed its high efficiency combustion system (HECS) engine that incorporates unique and traditional technologies to achieve low CO_2 emissions and a 17% reduction in fuel consumption, while also meeting Euro 6 emissions standards. The second-generation HECS has been adapted to a downsized 1.6L four-cylinder diesel engine and is designed for a high specific power output over 100 kW/L. To achieve this, FEV engineers designed a 200-bar peak pressure cylinder head with variable valve lift, realised via a unique roller finger follower that is adjustable for two different lifts; it also incorporates an innovative seat-swirl chamfer.



cylinder end of the laser module serves to protect the laser components from the high temperatures and pressures within the cylinder, and is self-cleaning, so long as a threshold ignition energy is maintained to prevent any progressive fall-off in laser intensity with use.

To save on cost and allow the use of a relatively large laser assembly, it would be advantageous in a multi-cylinder engine if a multiplexing system could be used, delivering pulses from a single laser to each cylinder in turn via optical fibres. However, at the laser powers required (pulse energy typically 10mJ to 100mJ for durations of less than 10ns, corresponding to a light intensity of around 100GW/cm2 at the beam's focal point), optical fibres are rapidly damaged. So a practicable ignition system for automobiles may have to use micro-laser modules, one per cylinder, of comparable size to a conventional spark plug, which are fed lower intensity light via optical fibre from a single pump diode source.

In 2009, a team from the Japan Science and Technical Agency (JST) described a Nd:YAG solid-state laser of this form factor able to deliver a single focused beam to the cylinder contents. Earlier this year, two of the same researchers (Professor Takunori Taira and Dr Masaki Tsunekane), with another from the National Institute for Laser, Plasma and Radiation Physics in Romania (Dr Nicolaie Pavel), announced the development of an enhanced ceramic micro-laser module (see photograph), capable of delivering three separately focused beams for enhanced ignition performance. This work was partially supported by the Japanese electronics supplier Denso.

Commenting on the research, Dr Geoff Dearden of the School of Engineering, Liverpool University, where research into laser ignition has been conducted since 2003, in collaboration with Ford Motor Company, said: "This is interesting work in addressing the system costs and packaging aspects of future miniaturisation of laser ignition systems and components. However, if I understand correctly from reading the published papers, the work so far has been done in a constant-volume chamber at atmospheric pressure and room temperature.

"For the concept to be viable, as with any optical window or interface at the engine cylinder entry point, the robustness of the material would need to be demonstrated under real engine conditions and laser ignition parameters. Also, the viability of using multiple low energy pulses to initiate and control combustion has yet to be tested. It is our view that there is much more research to be done on laser ignition and its use for control of combustion in car engines."

Lightweight inserts unveiled

PSM International has unveiled a patented,lightweight insert for cam covers, air intake manifolds and other thermoplastic injection-moulded applications.

"Engineers are looking for weight savings – even 20 grams per component is meaningful – so this aluminium product is our contribution to weight savings on a vehicle," said Ian Atkinson, managing director Europe for PSM International. A conventional inlet manifold can use as many as 15 inserts. "You need an insert to provide thread strength and other performance criteria you can't achieve by screwing directly into plastics."

Employing the aluminium Tri-Step inserts on a plastic inlet manifold eliminates approximately 60% of the weight that is associated with conventional brass inserts or steel inserts. The Tri-Step can be installed using either a preheating process or an ultrasonic heat-generating process and features a design that essentially eliminates both insert misalignment during installation and insert spring-back.

The first production application of lead-free inserts is en route. "We now have Tier 1 customers who will be specifying the aluminium Tri-Step insert for OEM components for next-generation projects," concluded Atkinson.

News in brief

Lighter active stabiliser system

A comprehensive programme of optimisation and advances in actuator technology has resulted in a 15% weight reduction in BWI's Active Stabiliser Bar System, making it applicable to smaller cars.

Cooper Standard JV

Cooper Standard has signed an agreement with Fonds de Modernisation des Equipementiers Automobiles (FMEA) to establish a joint venture that would combine Cooper Standard's French body sealing operations and the operations of Société des Polymères Barre-Thomas (SPBT). The joint venture entity, named Cooper Standard France, will be owned 51% by Cooper Standard and 49% by the FMEA.

TomTom speech recognition

VoiceBox Technologies Corporation and SVOX are providing speech input technology solutions for the newly launched TomTom portable navigation devices (PNDs) in the US and Canada: the GO (GO 2435, GO 2535 and GO LIVE 2535) and VIA series.

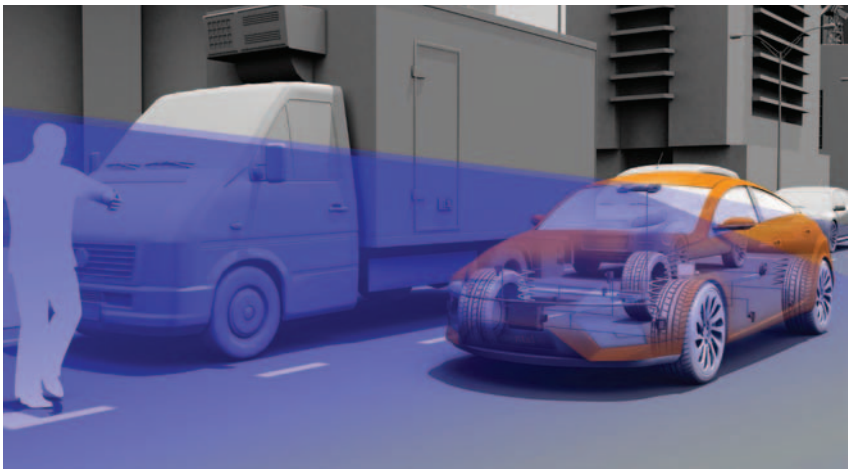
High-performance body parts

Bayer MaterialScience is offering a new green high-tech material blend of polycarbonate and polyethylene terephthalate (PC+PET) for horizontal automobile bodywork parts. The premium material is manufactured from high quality post-consumer and post-industrial recyclates. Possible applications are parts such as spoilers, boot lids and skirts, as well as covers for antennae and convertible top compartments.

Toyota partners with Microsoft

Microsoft Corp and Toyota Motor Corp (TMC) have forged a strategic partnership and plan to build a global platform for TMC's next-generation telematics services, using the Windows Azure platform. The two plan to participate in a €8.5 million investment in Toyota Media Service Co, a TMC subsidiary that offers digital information services to Toyota automotive customers.

Two eyes are better than one



Continental will add a stereo camera to its ContiGuard safety system as an integral element of its forward-looking braking systems.

It consists of two high resolution CMOS mono cameras, housed approximately 20 centimetres apart behind the windscreen. The stereo camera measures the distance to an object and its height from the road surface. This is possible, due to the differences in the perspective between the left-hand and right-hand optical paths.

The camera's software exploits the same effect that gives humans spatial vision – ie, the parallax shift between two images. At distances of 20 to 30 metres, the camera can determine the range to the object with an accuracy of between 20 and 30 centimetres.

It can also determine the direction in which every pixel of an identified object is moving along the horizontal, vertical and longitudinal axes. This six-dimensional identification makes it clear whether an object is moving and in which direction. Combined with object classification, based on common characteristics, this process invests the system with such a high standard of decision-making certainty that it is able to initiate emergency braking up to 1g, if the driver fails to react. The accuracy of the system enables the stereo camera to calculate the precise point of impact of a potential collision and to make the best possible use of the remaining time to prepare appropriate measures.

Other options are for a collision warning to be issued or for automatic braking to be applied earlier, if no evasive manoeuvre is possible. With its range of up to 60 metres, the stereo camera provides the best possible basis for developing braking systems that are truly looking ahead.

SMSC delivers low-cost controller

SMSC's lower cost OS81092 Intelligent Network Interface Controller is now available. "The introduction of OS81092 is the next step in the evolution of cost-effective infotainment solutions," said Dr Christian Thiel, vice president and general manager of SMSC's automotive information systems group. "The change in process technology from flash memory to ROM, the size reduction and the use of a highly effective QFN package will allow car makers and their suppliers to easily adapt MOST technology, while driving bill of material costs lower."

Free-form lenses from Docter Optics give

Automotive-Designers

creative freedom – for LED, HID or halogen headlights.

Headlights are unique design elements giving identity to automobiles and their manufacturers. And of course that is why designers focus on brand-driven design.

The world-wide unique Docter Optics DOC3D® glass molding technology has been the choice of preference for the production of standard optical glass lenses for years. The recent enhancement now supports also complex lens geometries to project the USP of your dedicated brand.

Docter Optics, the international market and technology leader for aspheres, arrays and free-form lenses for projection headlights, can help you design the vehicles of tomorrow. Sounds interesting? If so, contact us today.

www.docteroptics.com

DOCTER® OPTICS

Turning Ideas into Components

Avago launches first high-speed fibre optics

The Avago AFBR-1150 and AFBR-2150 MOST150 FOTs for automotive high-speed networks are said to be the first in production. Avago has successfully finished qualification tests of its MOST150 parts, which have received the final recommendation for release from RELNETyX, as well as from the MOST Compliance Listing.

One highlight of the qualification is that nearly no degradation of transmitter power after the 3000h High-Temperature Operating Life could be detected. The qualification confirmed excellent high-speed performance, even when driven by input signals showing strong jitter. The outstanding dynamic performance is a key factor for safeguarding automotive MOST150 systems.

"Avago has led the way in MOST150 fibre optic development, both with the production and qualification of our transceivers," said Martin Weigert, general manager of the industrial fibre product division at Avago. "Our lead customers have been very pleased with the robust, high-speed performance and jitter resistance of our FOTs."

Telemotive's latest data logger

Beside the interface for MOST50, the transportable blue PiraT 50M5C1SW2L also offers the possibility to record the Electronic Control Line (ECL). This speeds up the detection of ring-breaks and allows improved diagnostics, saving time during the development phase.

The Telemotive MOST50 data logger also has an interface for single-wire CAN, which would be of special interest for car makers using vehicle bus systems on a single-wire base. Furthermore, 5 CAN, 4 serial ports, 2 LIN, 1 Ethernet interface(s) can also be logged. Including client software enables the easy operation and conversion/export into various data formats.

The blue PiraT is also available with MOST25 and MOST150 interfaces, offering solutions for all MOST standards. In addition, there are variants of the blue PiraT available, with up to 10 CAN, 4 LIN, 2 FlexRay, 4 serial and 4 Ethernet interfaces.

That's infotainment: MOST 150 released

The MOST Cooperation – the standardisation organisation for multimedia and infotainment networking in the automotive industry and which consists of 16 international carmakers and more than 60 key component suppliers – has released the MOST150 Electrical Physical Layer Sub-Specification Rev. 1.0, based on coaxial cable.

"This MOST150 coax physical standard complements the existing MOST150 optical physical layer in the infotainment domain, especially for 10 OEMs who have stringent preferences in the electrical physical layer," explained Dr Wolfgang Bott, MOST's technical coordinator. "In addition, this new standard opens the way into other vehicle domains – ie, it fits into the driver assistance domain – as this physical layer is able to provide bi-directional 15 communication and power supply on the same cable."

This specification was derived in a straightforward process from the MOST Physical Layer Basic Specification. Its principal structure is similar to the existing MOST150 optical physical layer specification. Both layers are interoperable: MOST150 20 supports various physical layers and enables a variety of topology options.

MOST150 is a multi-channel network 25 (control data, synchronous and packet channel) that allows the parallel usage of all these services through one network. It provides, among others, an isochronous channel for video data transmission. It also enables IP data communication, providing the automotive-ready Ethernet channel, according to IEEE 802.3. 30, with freely configurable bandwidth from 0 to nearly 150 Mbit/s.

MOST150 supports the safety layer concept to enable fail-safe application up to SIL level 3, according to IEC 61508, and ASIL C, according to ISO 26262.

Daimler-Bosch joint venture announced

Daimler AG and Robert Bosch GmbH plan to expand their long-standing partnership, and cooperate in the development and production of electric motors for all-electric vehicles in Europe. The companies have signed a letter of intent and begun negotiations to establish a 50:50 joint venture, which is likely to be concluded in the first half of 2011.

In pooling their competencies, the two companies aim to accelerate development advances in electric machines, as well as benefit from synergies. According to their letter of intent, joint production should start in 2012. It is envisioned that the electric motors developed will be used in Mercedes-Benz and smart electric vehicles from 2012. Subsequent sales to other vehicle manufacturers are to be handled by Bosch. The joint activities are planned to be located in the greater Stuttgart area and in Hildesheim, Northern Germany.

Lexan helps to reduce emissions

Using Lexan polycarbonate glazing could cut CO_2 emissions by three grams per kilometre and extend an electric vehicles range by 2-3%, according to computational fluid dynamic (CFD) simulations carried out by SABIC Innovative Plastics' Exatec team.

The simulations were of two car configurations, one with a PC backlight and rooflight, and the other with a glass backlight and rooflight. Simulations were performed for both hot and cold climates, and considered stationary and moving vehicles. The results showed that the lower inherent thermal conductivity of PC glazing, relative to tempered glass, can reduce steady-state total heat transfer between the inside and outside of the vehicle.

Research and development by SABIC Innovative Plastics has resulted in a new family of Lexan polycarbonate resin products, with infrared energy-absorbing capability. They are formulated to reduce the amount of solar heat energy entering a vehicle's interior. By absorbing solar energy, these products can further mitigate the load on air conditioning systems, and help to improve fuel economy and lower emissions.

TRW has unveiled its new 'bag in roof' airbag system, which replaces passenger airbags typically mounted in the instrument panel. The new airbag can help cut passenger injuries.

MIRA and Drive System Design join forces

MIRA and Drive System Design (DSD) have signed a memorandum of understanding that will see the two engineering businesses collaborate on future projects where specialist transmission, driveline and gearbox design and development is required.

The agreement combines MIRA's existing advanced engineering, research and testing offer with Southam-based DSD's transmission expertise to cement MIRA's position as an innovative, single source provider of vehicle engineering services.

Commenting on the partnership, MIRA CEO Dr George Gillespie said: "This collaboration enhances MIRA's existing engineering capability, and ensures that we are well placed to meet future challenges and opportunities – such as low carbon vehicle technologies – which will require specialist transmission solutions."

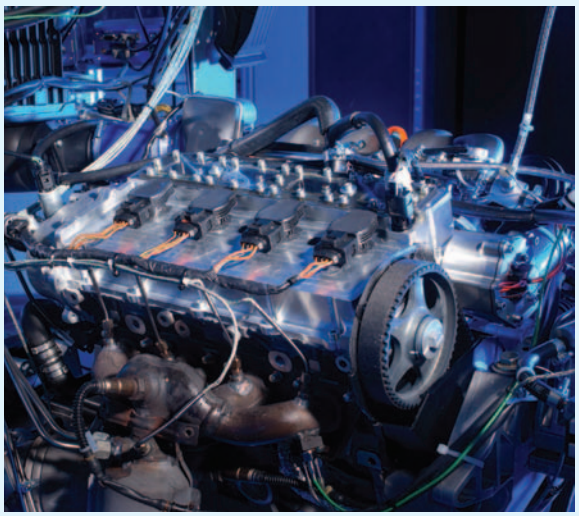
MIRA's collaboration with DSD is the latest of several agreements that have augmented its 'whole vehicle engineering' offer within the last two years. These include partnerships with Italian design house Torino Design, electric vehicle developer GEVCO and, most recently, noise vibration and harshness experts Brüel & Kjær.

Mark Findlay, managing director of DSD, added: "Our experienced personnel and modest size means we are nimble enough to adapt and exploit market opportunities and, by collaborating with MIRA, we become part of a wider vehicle engineering solution provider, with a global footprint."

Mark Findlay, managing director of DSD.

Timing right for acquisition

Kolbenschmidt Pierburg AG has acquired the rights to Entec Consulting GmbH Univalve variable valve timing technology. A purely mechanical system, "the fully variable valve control is a key enabling technology to reduce CO_2 emissions in the automotive industry, and we are convinced that this technology will play an increasingly important role in existing and future gasoline engines," said Dr Gerd Kleinert, chairman of the board of Kolbenschmidt Pierburg AG.



New packaging saves weight, improves power

Semikron has developed a revolutionary packaging technology for power semiconductors, which removes the need for bond wires, solders and thermal paste. The new SKiN technology is based on the use of a flexible foil and sintered connections. Current density is doubled to 3 A/cm2, compared with the 1.5 A/ cm2 achievable with standard wire bond technology. Converter volume can, therefore, be reduced by 35%.

This results in a higher current-carrying capacity and 10 times the load cycle capability – unthinkable with the wire bonding used in power electronics in the past. Wire bonding has been the main method of connecting the chip top-side connection to a direct-bonded copper (DBC) substrate for the past 25 years. Wire bonding cannot meet the need for higher current densities that has resulted from recent technical advances, meaning that reliability is impaired.

In the new packaging, a sintered foil replaces the wire bonding on the chips and the underside of the chip is sintered to the DBC. This results in optimum thermal and electrical chip connection, since sintered layers have a lower thermal resistance than solder equivalents. The sintered foil connects the chip across its entire surface, whereas bond wires connect the chips at the contact points only. Thanks to the high load-cycle capability offered by this new packaging technology, higher operating temperatures are possible. The move towards new materials, such as SiC and GaN, will increase the need for these elevated temperatures.

In addition to removing the need for wire bonding, the new packaging solution is free of solder thermal paste. Instead, a sinter layer replaces the thermal paste layer and the soldered base plate. Thermal paste is responsible for around 30% of the total thermal resistance in a system. By replacing this, the thermal conductivity between chip and heat sink is improved, resulting in a 30% increase in usable electric current.

JUST THINK: REGENERATIVE BRAKING SYSTEMS FOR EVERY CAR IN CHINA.

Cognitive Safety Systems from TRW can help protect people and the planet. A range of advanced safety technologies are helping to reduce emissions and improve fuel efficiency worldwide. TRW's Green Thinking – the safety everyone deserves.

ADVANCED THINKING / SMART THINKING / GREEN THINKING

COGNITIVE SAFETY SYSTEMS

http://cognitivesafetysystems.trw.com

TRW

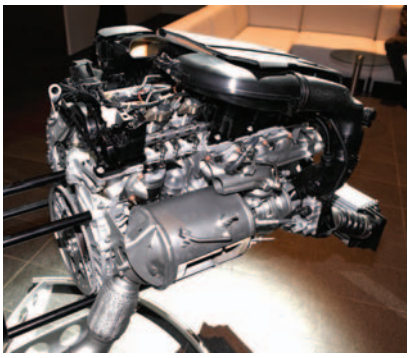
BMW developing modular engine range

BMW aims to cut the cost of production for its next generation of engines by using as many common parts as possible, while not stinting on the technology. The new family of three-, four- and six-cylinder engines goes on sale in 2014, and will be fitted into the entire BMW and MINI ranges in transverse (for all except the six cylinder) and longitudinal applications for all of them.

All the engines are turbocharged, employing recently introduced twin-scroll technology, and use similar four-valve, twin-camshaft, cylinder-head technology and aluminium cylinder blocks with sprayed steel liners. The aim is to reduce the complexity of the German car maker's engine range and gain economies of scale by using the same basic designs, ancillaries, installations and mountings, as well as making different engines on the same production lines.

"This means higher volume per [production] line, increased flexibility and quicker changes, in response to changing market demands," says Harald Unger, BMW's head of development for in-line engines.

"If we kept overall production the same, then we would need fewer plants," he states, "but our volume projections are for about 1.8 to



two million cars a year in four years' time and 98% of those cars will use the new family of engines." There will be six new engines, burning diesel or petrol, and BMW plans that each one will share the same swept volume per cylinder of about 500cc.

Petrol units will deliver between 60-100Nm torque per cylinder and between 30-50kW. Equivalent figures for the diesel units will be between 74-100Nm and 20-40kW. So the three-cylinder engine is likely to displace 1.5L, and deliver a minimum of 98kW on petrol and 60kW on diesel.

All the engines will use BMW's Vanos variable camshaft timing system and the Valvetronic inlet valve control system, and will share the same basic geometry of crankshaft-to-deck height and slightly long-stroke configuration. The camshaft drive will be moved to the rear of the engine to ensure a low bonnet line in longitudinal applications, and the engines will share over 40% of components between diesel and petrol units and over 60% between cylinder configurations using the same fuel. Balancer shafts will also be used to increase refinement: one on the three-cylinder and two on the four.

Although the company currently uses Mitsubishi Heavy Industries as lead supplier for its twin-scroll turbochargers and Bosch as supplier for its electronic controls, Unger says the contracts for the new engines are still completely open. "Everything is under review," he comments.

The new family is being developed for manual and conventional automatic gearboxes, and will have elements of future proofing, having a facility for future hybrid applications, as well as homogeneous charge compression ignition (HCCI) combined-cycle units, where an engine shares the homogeneous-charge characteristics of a petrol engine with the compression ignition of a diesel.

Dot peening move cuts cost and times

BMW is using Siemens' intelligent code reading system that employs dot-peened codes at its Regensburg plant in Germany, manufacturing blank Z4 bodies, as well as doors and tailgates for the 3-series.

BMW had been looking for a cost-saving solution to replace the previous microwave-based identification system. With that system, the entire body-building code – vehicle version, right-hand/left-hand drive, with/without through-loading system – was always carried on rewritable transponders. BMW decided on the Simatic VS130-2 system from Siemens, comprising an intelligent camera with integral image analysis and separate analysis unit.

In the body shop, components are identified with a 16x16 mm data matrix code (DMC). It contains the identification number stored in the production computer of the relevant vehicle and a unique part number. The latter is also imprinted in plaintext by the dot-peening device, in case the automatic detection system should fail.

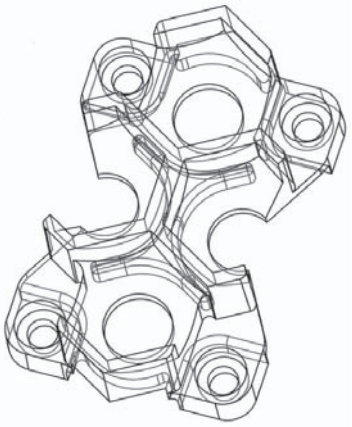
The Simatic VS130-2 code reader also includes a red ring light that guarantees optimal lighting conditions and is attached around the lens. Since reading sometimes has to take place very close to the object, BMW in Regensburg backs both 35 and 50 mm lenses with optional C or CS mounts to allow maximum flexibility in selecting the focal length and the field of view.

The code reader works with a CCD (charge-coupled device) chip, with a resolution of optionally 640x480 or 1,024x768 quadratic pixels. Image analysis takes place separately from the actual camera in an analysis unit.

BMW uses the Profinet I/O interface, integrated into the latest generation of the Simatic VS130-2 code reader. This enables real-time data transfer. In this way, the detection and analysis of the DMC, including data transfer to the computer, takes only 100 ms – making it faster by a factor of 1,000 than the previous microwave system that required 10 to 15 s. Added to this is the fact that the previous transponders are no longer necessary, halving system costs.

Real parts. Really fast.

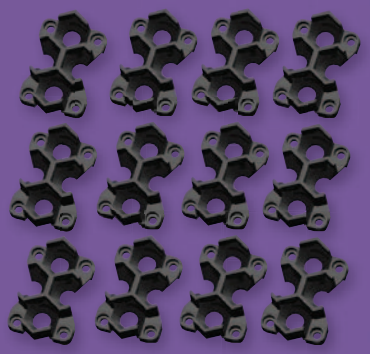
Simply upload your 3D CAD model, and choose the best option for your needs.



protomold®

Injection Moulding in 1–15 days.
Best for 10-10,000+ parts.
Priced from £995.

Choose from hundreds of engineeringgrade resins, including HDPE, Polypropylene, ABS/PC, Acetal, PBT, Polycarbonate, Nylon 66, Polyamide and LPDE.



firstcut®

CNC Machining in 1–3 days.
Best for 1-10 parts.
Priced from £50.

Choose from 30 different materials including ABS, Nylon, PC, Delrin, PEEK, ULTEM, and aluminium.

It's easy to work with Proto Labs.

Choose CNC machining or injection moulding, whichever is best for your project. Upload your CAD model and receive an automated, interactive quote in hours. Once approved, our cluster computing technology and automated manufacturing systems will deliver real parts using real materials in as little as one day. And that's the real story.

THE QUEEN'S AWARDS FOR ENTERPRISE: INTERNATIONAL TRADE 2010

proto labs®
Real Parts. Really Fast.™

Visit **www.protolabs.co.uk/parts** today to receive your FREE copy of our comprehensive comparison of rapid prototyping technologies. Enter source code EUAD11.

Call **+44 (0) 1952 683047**
or visit **protolabs.co.uk**

Quick-fire reaction

Ian Adcock talks with Reaction Design CEO Bernie Rosenthal about the company's ground-breaking computational fluid dynamics package for combustion analysis

Even after more than 100 years of development, and the massive steps forward in sophisticated software and increasingly powerful computers, the ability to predict accurately what happens when fuel is ignited in a combustion chamber is still something of a mystery to engine designers.

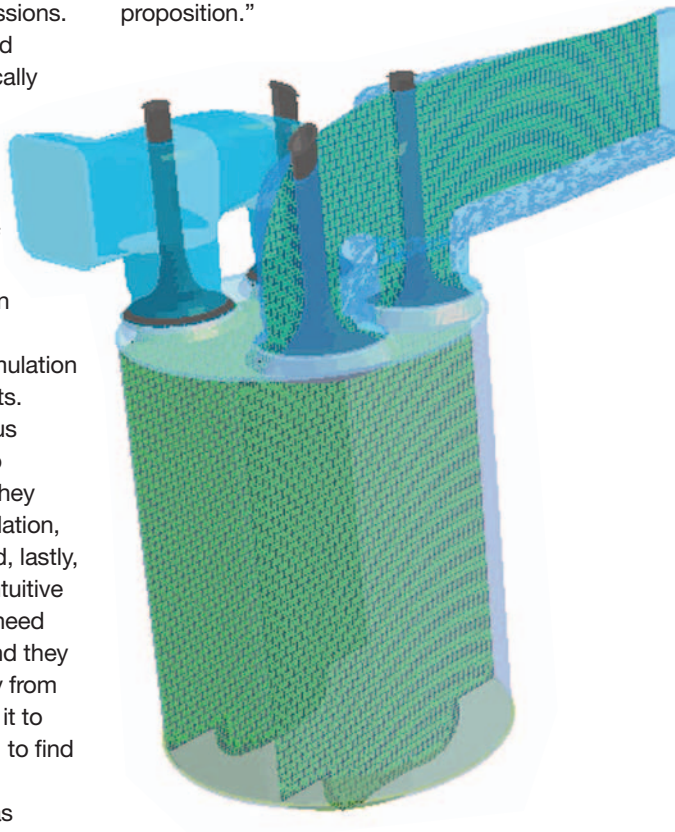
"We've seen a requirement storm brewing for a few years now," says Reaction Design's CEO Bernie Rosenthal. "Not just climate change, but also financial considerations, materials security and health concerns. That's driven requirements down to engine designers to comply with tighter emissions regulations, including particle size, changing fuel combinations and global differences in the make-up of certain fuels, as well as future fuels such as second and third generation bio-fuels."

Rosenthal and his team "see the engine as a chemical power plant, where you basically mix fuel and air, and get the chemical combinations of CO2 or NOx, particulate matter, unburnt hydrocarbons, etc, as a result."

Before they started developing the new FORTÉ Computational Fluid Dynamics (CFD) package, they went to the engineering community to discover what challenges designers faced with available software packages. "They asked us for three things: accuracy, as they couldn't reliably predict ignition or the effect of different fuels, never mind emissions. Some of the models being used require calibration, which basically means you almost need to have built an engine before you can figure out if you've modelled it correctly, which kind of defeats the purpose of modelling. Secondly, they asked for faster time to solution – the overall time spent by the engineer from set-up of the simulation through to visualising the results. These guys are under enormous pressure to get new engines to market. The subtext was that they were generating input for simulation, which was taking too long. And, lastly, they were looking for a more intuitive design flow where they didn't need multiple tools to do their job and they were able to reliably walk away from the simulation overnight, allow it to work and return in the morning to find the result."

What engineers wanted was predictive solutions, rather than an explanation of what had been built. Commercial approaches, such as those employing red cued and simplified models, or populating tables that use software to deliver the answers, weren't sufficient. "We saw people dealing with this in non-reactive flow simulations that didn't take into account any of the fuel-mixing effects or the combinations of the chemistry in the engine. Basically, looking at the turbulent flow inside the cylinder and then using experimental testing to try to understand how different fuels might affect that behaviour and, lastly, we saw people saying they will deal with this in the after-treatment system," says Rosenthal.

Effectively, he points out, it was trading off simulation accuracy versus the time it took. "If you use enough detail to give you confidence in the results, it takes too long and you get to the point where it's not practical in the development timeframe. If you're looking for accurate outputs, you need accurate inputs to start with and that's a pretty complicated proposition."



Bernie Rosenthal

CV

Bernie Rosenthal is president and chief executive officer of Reaction Design. Previously, he was co-founder and senior vice president in charge of worldwide business operations at Tensilica. Prior to that, Rosenthal held various executive and management positions at Synopsys, AMCC and TRW. He graduated from the University of Southern California, receiving a BSc in Electrical Engineering, an MSc in Industrial Systems Engineering and an MBA. Aged 51, Rosenthal resides in northern San Diego with his wife Irene and two teenage daughters.

Engineers were telling Reaction Design's team that real fuels were too complex to model accurately and they didn't have reliable models as to how the fuels would act in the cylinder.

FORTÉ was hatched from a Reaction Design-led, industry-funded project called the Model Fuels Consortium (MFC). When starting MFC in 2005, Reaction Design discovered an absence of models of what fuel chemistry really looked like, so they assembled a consortium of suppliers and what Rosenthal describes as "demanders of energy" to develop accurate fuel model chemistry mechanisms for use in this simulation, whether that's diesel or petrol. "We started with seven or eight companies and that has now grown to over twenty, including VW and PSA, as well as a number of Japanese and American OEMS, and we're adding to the consortium on an annual basis," states Rosenthal.

The idea behind Reaction Design's pioneering concept of surrogate fuels is that fuels are composed of classes of different chemical molecules and every structure has a different behaviour, as Rosenthal explains. "If you find a representation of a fuel molecule, you can represent the behaviour associated with the class of the molecule, which is the case across all fuels. Even if you look at the alternative fuels coming in, you can represent those as sub sets of what they really are."

The team has also developed surrogate blend optimisation software that takes the octane or cetane rating as one of the inputs, allowing engineers to describe some of the basic formulations and take into account variations from one part of the world to another, or if it's a heavier or lighter mix.

Also, they've started to add basic ethanols and second generation bio-fuels. "As they roll in, we're adding them to the database," he says.

The problem is that, once you exceed 1,000 chemical species, it can takes weeks to get a solution for one engine cycle and that's even more impractical. "It can take upwards of 80% of the calculation of that engine cycle; that's an area which is being ignored, because engineers haven't got the time to get the answers. Under pressure and ignition, the flow changes, the temperature gradient changes, so we have tens of thousands of calculations that have to be included and project what the molecules are going through.

"The complexity of both the mechanical and chemical process, and the way that, for example, when you inject a spray how it is disseminated in the cylinder, has a bearing on all the factors you're interested in, such as the temperature, where the flame starts and how it propagates.

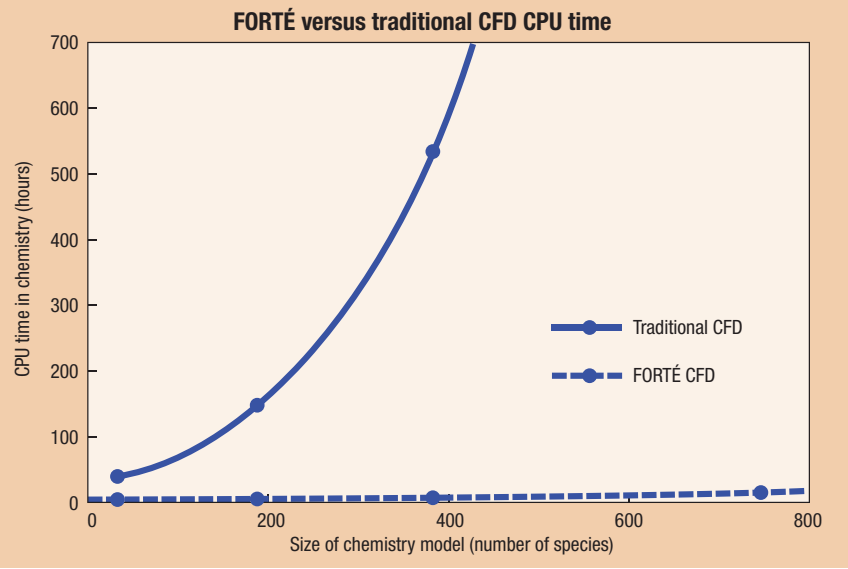
"There are a number of complex physical and chemical facts taking place in the engine during the cycle, so you have to be able to manage them all," he points out.

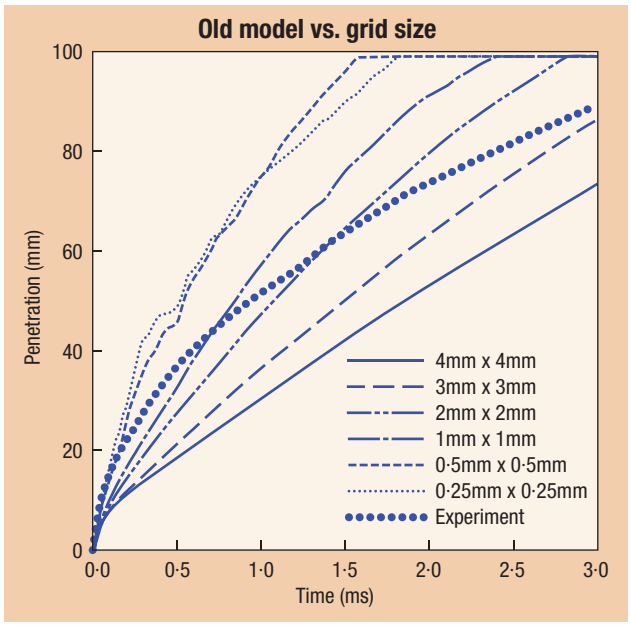
Reaction Design, explains Rosenthal, "had to go back to the drawing board and break new ground on how those chemical equations were solved, to the point where we had to bring together some numerical-solving algorithms that haven't typically been used.

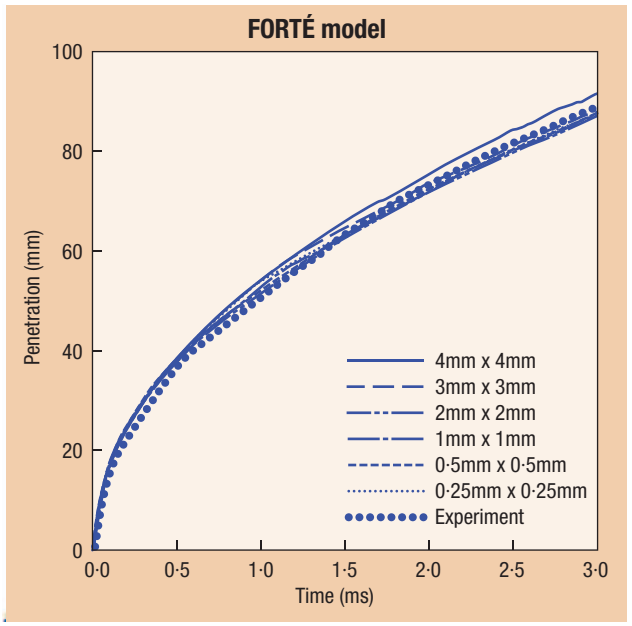
"We were successful in grouping the complexity from an exponential relationship to a linear relationship. This basically says that previously, when you went from 35 species up to 150, the time it would take to simulate that model would increase by nearly a factor of ten. To reduce complexity, we employ an 'on the fly' reduction mechanism that uses a smart algorithm that looks at the next cell simulation and decides whether the chemistry in that next cell is required for the solution. If it's not, we don't use it. Another thing is cell clustering where, if it has already calculated the chemistry for a particular cell and it's the same chemistry in an adjacent cell, it doesn't recalculate, but just reuses the answer."

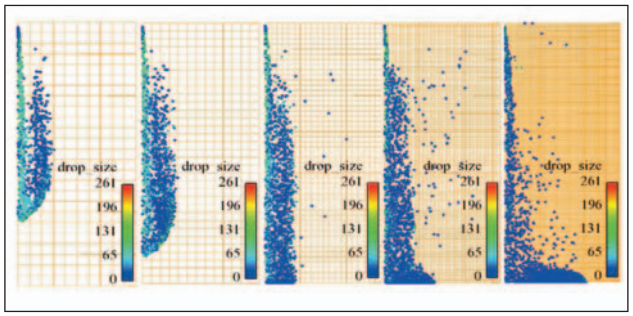
FORTÉ uses a mesh model for spray droplets that's intolerant of grid size, resulting in higher accuracy and, because it's a very coarse grid size, reducing the amount of calculation and subsequently simulation time. It also employs an auto-mesh generation feature that works around geometric boundaries, with local meshing around the system's edges or the injector nozzles to allow the preview of mesh upfront before the simulation.

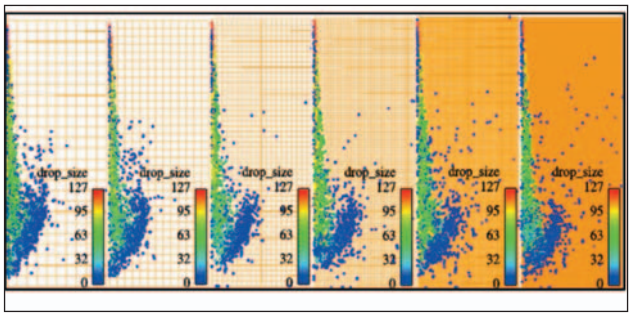
Unlike many auto-meshers that employ odd-shaped cells that are hard to populate mathematically and are computationally intensive, or a cut cell approach that can result in











rounding errors, FORTÉ employs a fully rectangular or Cartesian cell with an immersed boundary approach that contains all the data and then eliminates that which isn't germane to the calculation, as opposed to other approaches where missing data is inferred.

This, claims Rosenthal, has a "large" effect on both accuracy and reducing simulation times – from 133 to 13 hours. "The set-up is more straightforward, with a lot less time to calibrate to make sure the spray model is correct and you don't have to export to another set of tools. So overall there's a 25-50% improvement in the time to solution."

Rosenthal claims FORTÉ is the only tool available today that can handle multiple injections of multiple fuels. "We're working with European and American vendors that are looking at mixing diesel with gasoline or natural gas and getting some very interesting results, including a dual gasoline-diesel engine that runs 35% more efficiently than the standard engines."

And since FORTÉ can lead to the creation of engine designs that result in a cleaner, more complete burn, it could help minimise catalyst loadings.

"I think we can get more detail and insight into how much we can eliminate in the cylinder before it gets out to an after-treatment and that's where a lot of the value of this is shown."

FORTÉ, he maintains, could help speed up the development and understanding of advanced engine technologies, such as pre-mixed charge compression ignition (PCCI), homogenous charge compression ignition (HCCI) and dual fuel systems, "It helps engineers to understand what's happening in HCCI to make the switch over smoother. Much of the work we see today is some form of charge compression ignition, HCCI or PCCI." Meanwhile, energy suppliers could also benefit from FORTÉ's capabilities to understand further how fuels are burnt, in order to deliver even cleaner and more efficient fuels to the end users.

"We've been working with some of our partners for six to nine months, so we're still a couple of years out, but we're getting feedback that it's already altered design frames.

"One of the things we've done is allow people to import experimental data and create views next to modelling data, a closed loop system – and take a look at projected versus what's being seen on the test bench and then modify the model's parameters or some of the environmental boundaries. That's the last piece of what engineers were asking for."

SAE International®

— now offering professional development training and education in Europe.

Invest now in your education — stay current on technology, increase your knowledge, and positively affect your organisation's results with professional development from SAE International.



We are expanding our Professional Development Courses to Europe through a schedule of courses on topics and technologies that are relevant to European industry.

Birmingham, UK – 19 – 23 September 2011

- **Engineering Project Management**
  19–20 September
- **Introduction to Hybrid and Electric Vehicle Battery Systems**
  19–20 September
- **Fundamentals of Modern Vehicle Transmissions**
  19–21 September
- **Vehicle Dynamics for Passenger Cars/Light Trucks**
  19–21 September
- **Design Reviews for Effective Product Development**
  21 September
- **Safe Handling of High Voltage Battery Systems**
  21 September
- **Advanced Vehicle Dynamics**
  22–23 September
- **Internal Combustion Systems: HCCI, DoD, VCT/VVT, DI and VCR**
  22–23 September

Turin, Italy – 31 October–8 November 2011

- **Advanced Diesel Particulate Filtration Systems**
  31 October–1 November
- **Selective Catalytic Reduction for Diesel Engines**
  2–3 November
- **Threaded Fasteners and the Bolted Joint**
  2–3 November
- **Principles of Cost and Finance for Engineers**
  2–4 November
- **Vehicle Accident Reconstruction Methods**
  7–8 November

"Early Bird" discounts available

Don't miss out on registration discounts for these courses!

Register now and benefit from the savings.*

** Members of SAE also obtain further discounts*

For more information and to register
visit *www.sae.org/training/europeseminars*

Or contact our SAE International Europe Office
Avenue de Tervueren, 300
B-1150 Brussels, Belgium
E-Mail: EuropeTraining@sae.org
Tel: +32 2 740 2223
Fax: +32 2 743 1550

P110865

David Schutt, The Columnist
SAE International Chief Executive Officer

Building the sector knowledge base

SAE International prides itself on serving all sectors of mobility engineering – aerospace, automotive and commercial vehicle. Each discipline requires a different and unique set of knowledge and training; we work hard to provide that information in an efficient and cost-effective way.

But these three sectors also have much in common. Often, they share the business challenges that face organisations today. All three were hit hard by the global economic crisis of two years ago – the recovery is ongoing.

That crisis greatly changed how organisations do business. It impacted how much money those organisations have to spend on research and development, and it impacted the overall knowledge base of the organisations as well. How? Many companies had to reorganise and downsize to stay competitive and reposition for the future. When that happens, talented and creative people have to be let go. Such actions can cause a knowledge drain or a knowledge void for the organisation.

It is imperative to address such a loss of knowledge, because, if left to go unchecked, it can hamper even the best recovery plans. We understand that at SAE International, and many of our programmes, products and services are geared to help 'refill' that knowledge base. Bob Sechler, SAE International's manager of education relations, and his team are constantly busy creating and coordinating the Collegiate Design Series competitions for college students across the world. This series of events challenges students to work together as a team to design and build remote-controlled airplanes, Formula cars, Baja vehicles, environmentally friendly snowmobiles or super-high gas mileage vehicles, under a strict set of engineering and budget criteria. It is real-world learning at the university level. It also prepares these students to step right into the professional world and immediately be effective team members, because they have a unique level of skill sets.

For the seasoned professionals who may be at a crossroads and need to enhance their skills sets, SAE International, again, can help to provide the answers. Kevin Perry, manager of professional development, leads a team of staff members who create sets of learning seminars, products and tools designed to enhance current skills and provide new ones. The courses are created to be cost effective and convenient. And, most importantly, they are created to help the individual keep moving forward professionally.

For organisations that may have suffered a knowledge drain, or for organisations that want to bolster their overall employee learning competency, Perry and his team offer in-house corporate learning solutions. These programmes provide administrative coordination from SAE International; customised training options, tailored to relate directly to a company's business; and continuing education units to all attendees.

> "Many companies had to reorganise and downsize to stay competitive and reposition for the future"

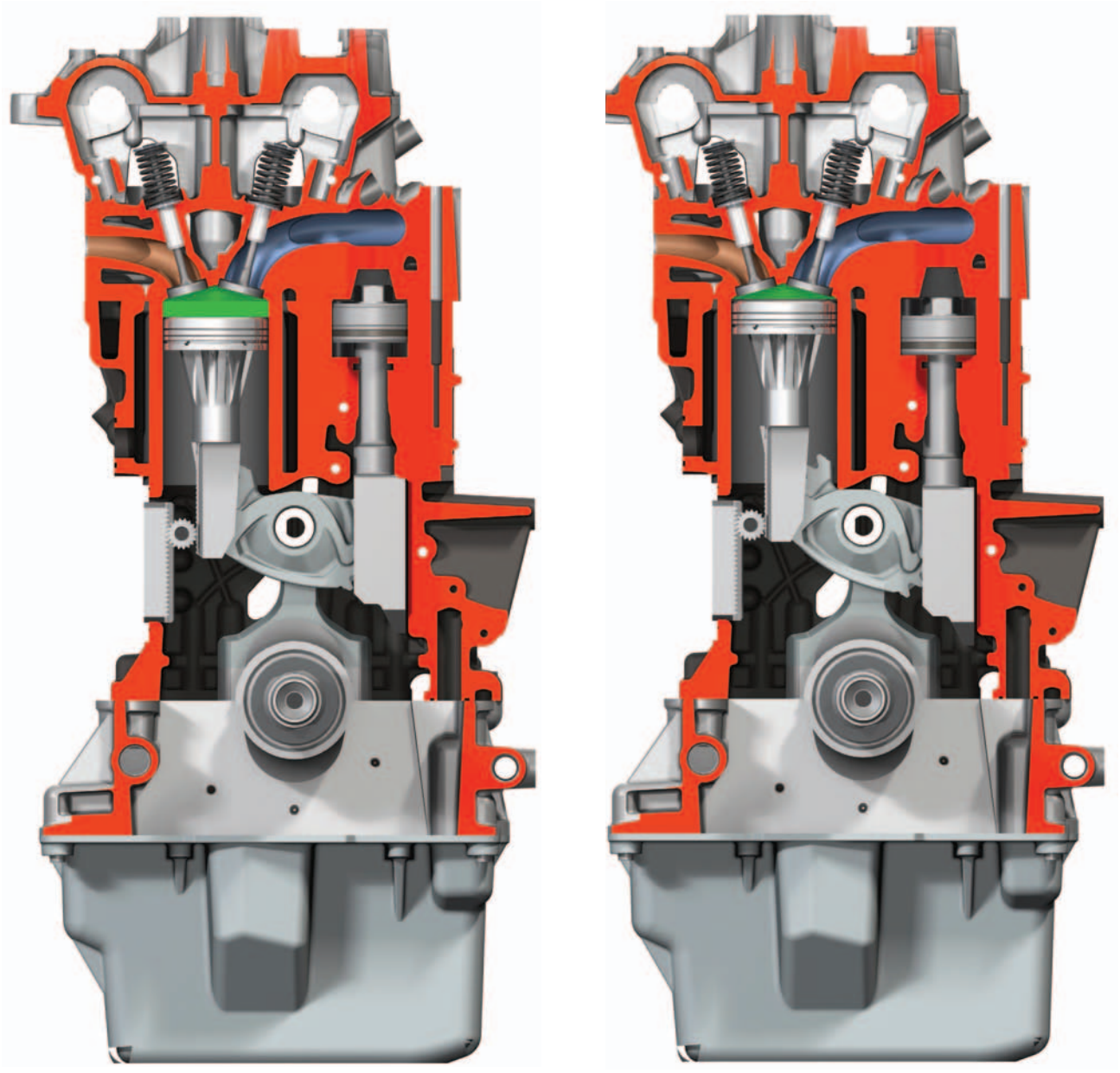
The common goal among all of these programmes is to help mobility engineering organisations and professionals stay competitive in a challenging business environment. And that goal reaches across the spectrum of mobility engineering.

SAE International has the tools to help organisations and individuals build upon the knowledge base they already have and forge a continuing education for the future.

focus@sae.org

CONSUMPTION: The Mother of Invention

It's a challenge that has engaged the minds of many down the years: changing the compression ratio in an engine on the fly. In these fuel efficiency-conscious times, a breakthrough was never more needed. William Diem reports



Changing the compression ratio in an engine on the fly is an idea that has been around for decades without successful industrialisation, but its potential for improving fuel consumption means that it continues to attract investment.

Variable compression ration (VCR) "offers the largest potential improvement in part-throttle fuel efficiency and CO_2 emissions, when compared to other competing technologies, if applied to highly pressure-charged downsized engines," concluded British engineering firm Prodrive in a 2002 SAE paper. And today, with all automakers in the world looking for ways to reduce consumption, without harming customer satisfaction, is the right time for invention.

Small engineering companies in France and The Netherlands are aiming at just that market. In Lyon, France, MCE-5 Development S.A. is refining a technique to vary the compression in a petrol engine from 6:1 to 15:1, depending on the driver's demand for torque. Combined with direct injection and supercharging, VCR could improve fuel efficiency by 15-20%, says Vianney Rabhi, the inventor and founder.

Meanwhile, in Naarden, The Netherlands, Gomecsys BV inventor and technical director Bert de Gooijer is demonstrating a supercharged two-cylinder, 800cc engine, producing 95kW and 150 Nm of torque, in which compression ranges from 7:1 to 18:1, reducing fuel consumption by 18%.

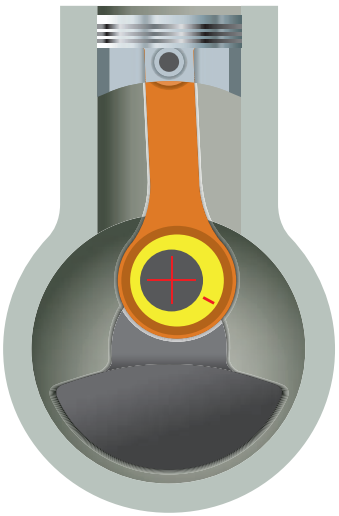
The fuel efficiency potential within VCR comes from the fact that all fixed compression ratios are a compromise between what the engine needs at full throttle and what it needs at part throttle. The threshold of unwanted detonation at wide open throttle limits the maximum useable compression ration to 11:1 or 12:1. But at part throttle – the situation at cruising speeds – compression could be higher, because the temperatures and pressures in the cylinder are much lower.

Vianney Rabhi: "It takes three combustion cycles, about 0.3 seconds, to change the compression ratio. ... Most of the time, the VCR waits for the turbine to react."

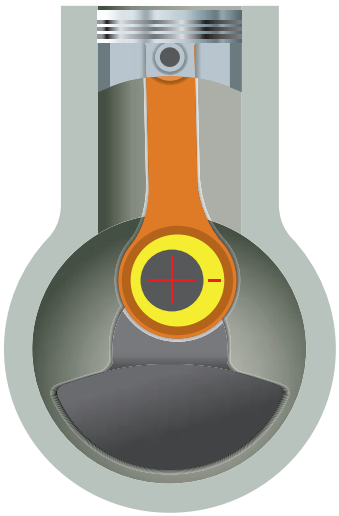
"VCR is a way of enabling aggressive downsizing, without downgrading performance," says Kean Harrison, team leader for advanced engines and hybrids at Prodrive. "Most VCR systems have been quite cumbersome: interesting academically, but not that feasible."

Automakers and inventors have patented many ideas over the years. None has reached series production, but Saab Automobile demonstrated a variable compression engine to journalists in 2000. When the hinged cylinder head was tilted hydraulically,

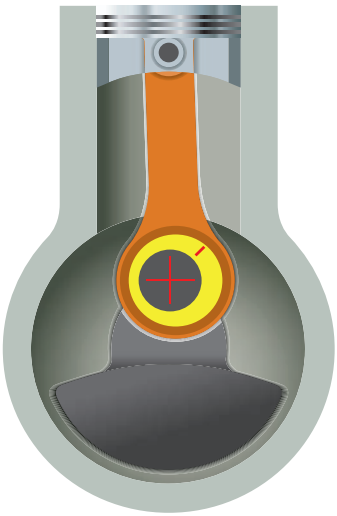
At minimum compression ratio (opposite), hydraulic pressure on the control jack is released, permitting the teeter-totter gear wheel to descend on the left side, increasing the unswept volume of the cylinder (in green). At maximum compression in the view, right, the control jack is forced down, raising the piston in the combustion chamber and reducing the dead volume. The Gomecsys system of gears (below) changes an eccentric bearing that raises or lowers the con rod. The gearing system actually reduces friction inside the engine for an additional contribution to fuel efficiency.



Eccentric at –30 degrees compression ratio 8:1



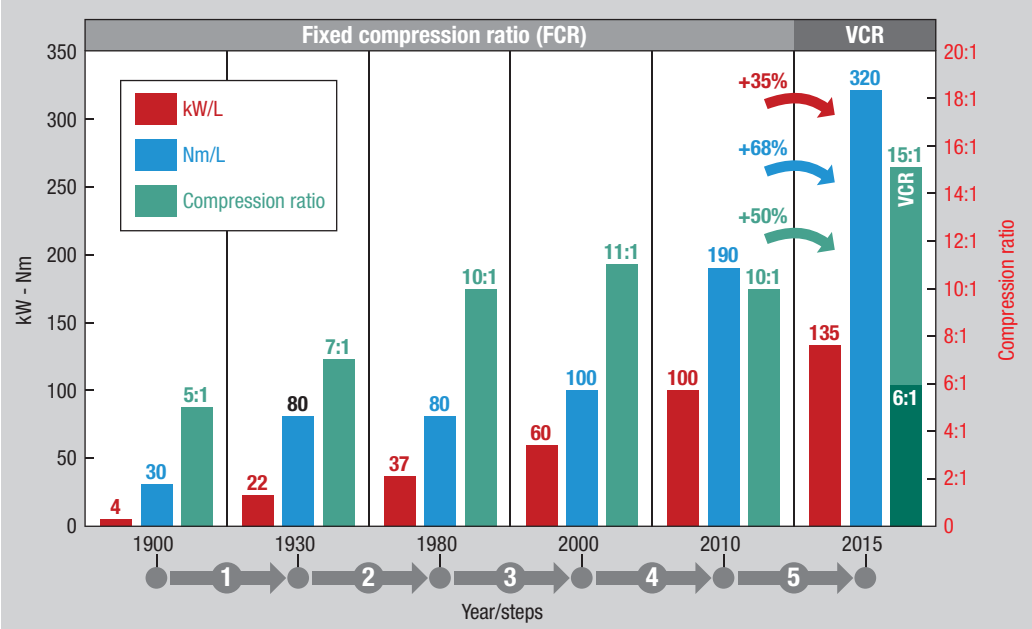
Eccentric at 0 degrees compression ratio 12:1



Eccentric at 45 degrees compression ratio 16:1

the volume in the cylinder changed, while the stroke remained the same. However, Saab was at the time run by General Motors, who killed the project.

Prodrive's 2002 paper reviewed patents filed by Ford Motor Co., Volvo Car, Daimler AG, Nissan Motor Co, PSA Peugeot-Citroen, Mayflower and others. The ideas under review included a moving cylinder head, variation of combustion chamber volume and of the piston deck height, modification of the connecting rod geometry, moving the crankpin within the crankshaft to vary the stroke and moving the crankshaft axis.

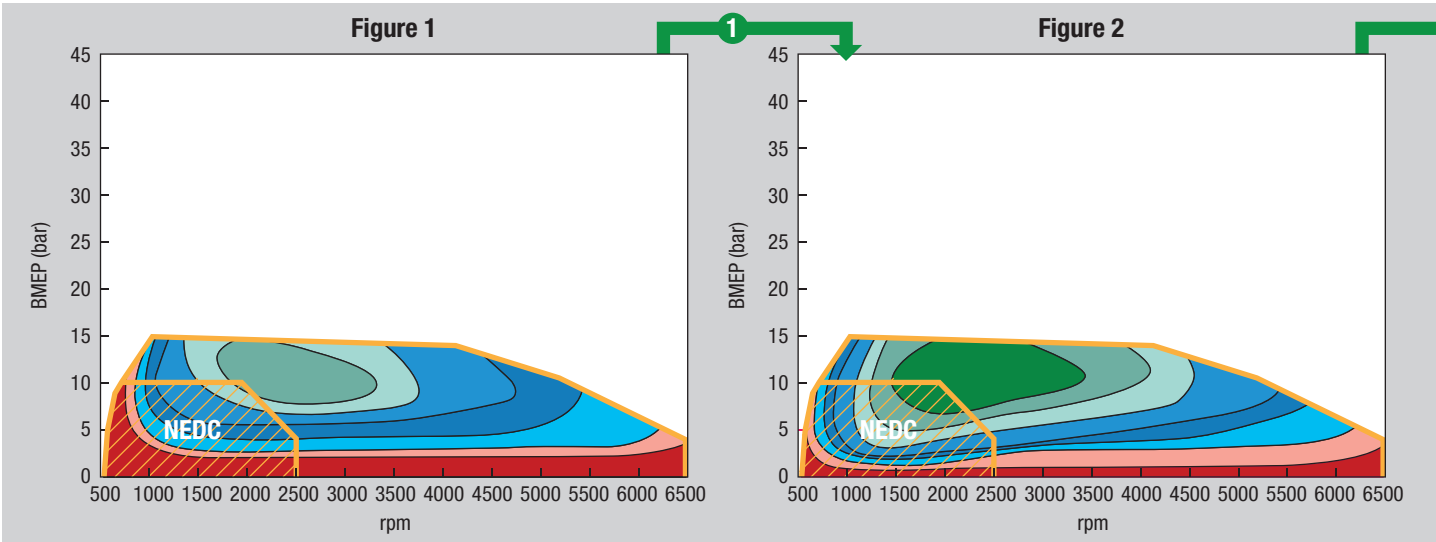


Rahbi's system in France involves a modification of the connecting rod geometry, and the theory has moved off the test bench and into two Peugeot 407s.

MCE-5 has built nine engines by hand so far. The 1.5-litre, four-cylinder test engine produces 162kW and 420 Nm of torque at 1800 rpm, giving the cars the feel of a diesel. Fuel consumption in the demonstration vehicles is about 150 g/km of CO_2. In the 2010 Peugeot 407, with a 2.6L 157kW V6 and 290 Nm of torque, fuel consumption was 233 g/km.

Rather than the crankshaft, the connecting rod is attached to a hinge or teeter-totter, known as the gear wheel, which is connected to the crankshaft. A second rod, or control jack, is connected to the other side of the hinge and controlled hydraulically by the engine controller. When the control jack is forced downwards hydraulically, the gear wheel tilts and pushes the piston rod and piston higher in the cylinder, resulting in a smaller volume and higher compression. Internal losses are small, because the system uses forces available in the engine to control the hydraulics, rather than a separate pump.

To improve fuel efficiency in an engine, one can move from Figure 1 to Figure 2 by reducing heat, pumping and friction losses and optimising gas expansion. The major improvements arriving at Figure 3 come from increasing the engine's specific torque and power, which permits downsizing and downspeeding. Turbocharged GDI engines use this approach to gain 15-20% efficiency and MCE-5 believes that, by adding variable compression, another 15-20% can be gained.



Swept volume remains the same – 84mm in the test engine – while the dead volume at the top of the cylinder can be made larger or smaller. “Each cylinder can be independently controlled,” notes Rabhi. “It takes three combustion cycles, about 0.3 seconds, to change the compression ratio. … Most of the time, the VCR waits for the turbine to react.”

The advantages of VCR are minor, in the case of a naturally aspirated engine, perhaps 3-5%, says Rabhi, but “with forced intake, we gain up to 35%, in comparison to a naturally aspirated engine, and, in comparison with a GDI turbo, which already has made improvements, we will gain between 15% and 20%.”

The Dutch engineering company is displaying its third generation engine in a Mitsubishi Colt and, “we are getting good results for fuel reduction”, says Bert de Gooijer.

The system involves a new crankshaft, in which eccentric bearings, controlled by a fixed ring gear at the front of the engine, can lift or let fall the bottom of the connecting rod. A series of gearings means the bearings change position at half the rotation speed of the crankshaft, which actually reduces internal friction losses in the engine. Compression can be reversed from highest to lowest in half an engine cycle under hard acceleration and the change from low to high compression take two complete cycles. Implementing the system in an existing engine will require the new gears, a small electric motor to adjust the controlling ring gear and a new press-fit crankshaft, rather than a solid machined one common today.

“Harley Davidson uses a press-fit crankshaft, so the process is known,” adds de Gooijer. “But, for OEMs, it is a big step to change that.”

Philippe Coblence, the Renault powertrain engineer who used to run Renault’s F1 engine programme and was the architect of the automaker’s newest 1.6L Energy dCi 130 going into the Renault Scenic and Nissan Qashqai this summer, says that “variable compression is a good idea, but it is difficult to realise”.

The problem for an OEM is to assure durability and reliability in series production, and Prodrive’s Kean Harrison points out that, in the future, US rules on emissions will require manufacturers to warranty their powertrains for 15 years or 240,000 km (150,000 miles).

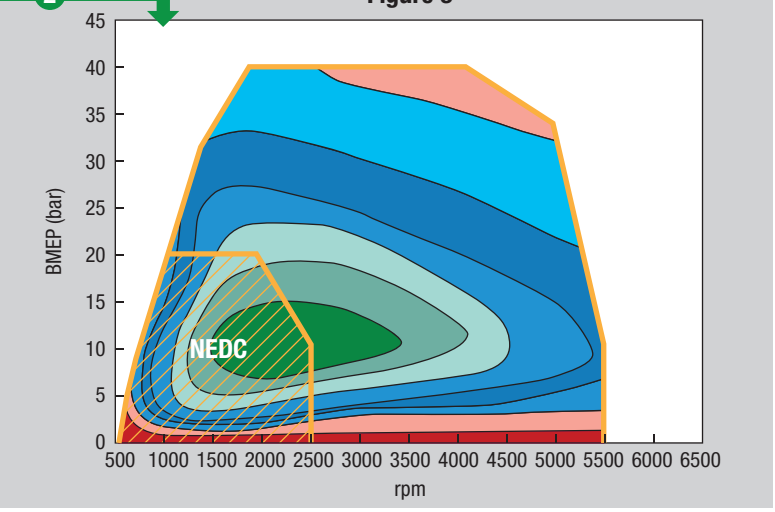
Prodrive worked with Gomecsys on its first generation engine and Harrison liked the simplicity of that approach, while new linkages, as in the MCE-6 engine, might be more liable to failure, long term, exposing a manufacturer to financial risk. Both MCE-5 and Gomecsys are now talking with automakers about licensing their inventions. MCE-5 had a development deal for several years with PSA Peugeot-Citroen a decade ago, but has since been on its own.

The two companies have different ideas about what the first production VCR engine might look like. De Gooijer believes it will be a high volume, in-line 2- or 3-cylinder engine, because that would bring the fastest fleet reduction of CO_2 emissions. An engineer at MCE-5 thinks it will be a small-volume, high-power engine for a niche vehicle, because that would limit a manufacturer’s investment risk.

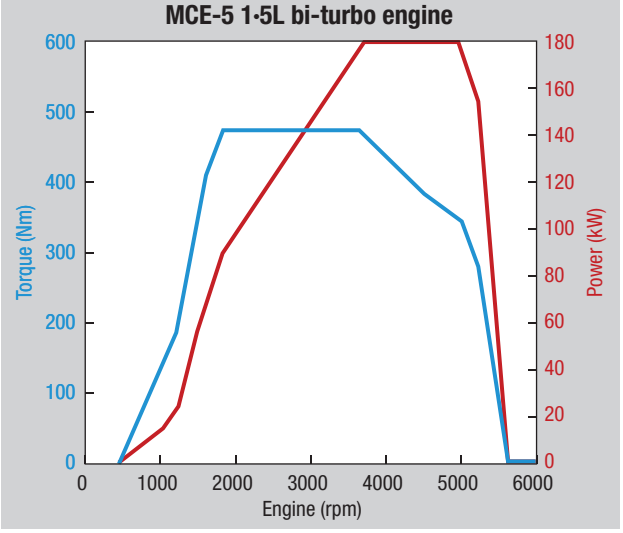
In any case, Harrison adds, “now is the time” for these developments to get a hearing in OEM powertrain departments. “There is enormous focus on new technologies.”

2

Figure 3



MCE-5 1·5L bi-turbo engine



Seeing the way

Lighting systems are becoming increasingly complex, but at the same time they need to be more efficient to help minimise CO_2 emissions, as Keith Howard discovers

Night driving is an issue that concerns many motorists, whether or not they know about the statistical evidence suggesting that accidents are about twice as likely to occur at night as during daylight hours, despite the lighter traffic.

When automotive lighting company Sylvania polled drivers in the US, almost a fifth reported sometimes avoiding night driving, because of visibility issues.

It's not a concern that is lost on car makers or their lighting component suppliers. The more precise control of beam pattern provided by complex surface reflector design and the introduction of high intensity discharge (HID) xenon headlights, which generate about 30% higher light intensity than conventional halogen alternatives, have been steps in the right direction – although, 20 years after its introduction, HID technology remains too costly for standard fitment on cars of all classes.

Further substantial improvement rests with the development of a new generation of adaptive headlight technologies, such as the Highbeam Assistant system supplied by Automotive Lighting GmbH for the Mercedes-Benz S-Class, Hella's Dynamic Light Assist (Audi A8, Mercedes-Benz S-Class and Volkswagen Touareg) and Valeo's BeamAtic Premium system, premiered on the Volkswagen Phaeton.

Whereas first-generation adaptive lighting improved visibility by directing illumination to follow the road more closely, these new systems take the more radical step of using as extensive a beam as possible, for as much of the time as possible. They do this by detecting when other cars are ahead or oncoming and automatically protecting them from glare.

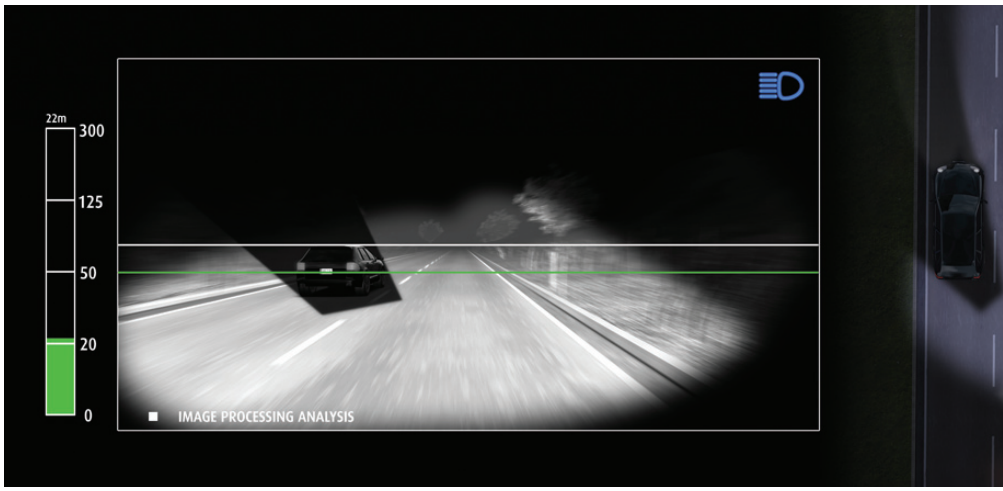
According to research commissioned by Valeo, average high beam usage with its base BeamAtic system – which controls the switching of conventional dipped and main beams automatically – jumps from 8% of the time (with manual control) to almost 40%. Automotive Lighting's Highbeam Assistant is more complex, in that it is able to vary the beam cut-off in discrete steps, according to the distance of other vehicles, by using actuator motors to vary the angle of the projector module.

This facility is also used to implement a motorway light above 90km/h, with raised light-dark boundary and output of the xenon module increased from 35W to 38W.

With BeamAtic Premium and Hella Light Assist – examples of the most sophisticated such systems currently available – main beam is used continuously, with a cylindrical screen within the headlight, positioned between the light source and projection lens, being automatically adjusted by a stepper motor to ensure that other vehicles are selectively protected from glare, their drivers seeing what appears to be a dipped beam.

Cost is again an issue with these technologies, since a camera is required, together with an ECU running sophisticated image processing software. But duty-sharing offers a measure of relief, in that the camera can also be used for other functions.

The next significant development will be the adoption of LED light sources in these systems. LED technology's attractions are well established and the pace of development of high-output LED modules has been surprisingly rapid. LEDs last the lifetime of the car – a bonus not just in that it removes the need for bulb replacement, but also as it avoids progressive fall-off in



to a brighter future

Advances in LED and HID technology are resulting in more sophosticated headlight systems (above, below)

performance. Moreover, because LEDs generate 'cold light', without accompanying heat, they are also more efficient. The two-LED low-beam modules in the Nissan Leaf EV, for example, consume 50W, compared to 90W and 130W respectively, for comparable xenon and halogen units.

By 2015, Valeo reveals, it fully expects that ongoing development will reduce LED power consumption by 25%.

This high efficiency also makes LEDs the obvious choice for meeting the EU running light regulation that comes into force in Europe later this year. Using dipped beam headlights as running lights is doubly inefficient, as the beam is both too powerful and directed away from other road users. Low-power LEDs that are not bright enough to cause glare can be directed towards other road users, ensuring maximum efficacy and minimum impact on fuel consumption and CO_2 generation.

LEDs have already been used in adaptive lighting systems as a supplement to xenon main units. Automotive Lighting's aforementioned S-Class installation uses twin LEDs with rotating reflectors for the cornering light function that improves visibility when negotiating tight bends or junctions, or turning into drives.

But LEDs also offer the potential for what Valeo describes as "bending light systems without mechanical movement" – in other words, adaptive lighting systems comprising an array of LEDs, each of which contributes a different part of the beam pattern.

"The DLA system can use the same mechanical components, together with LEDs or a matrix system, switching on or off the single arrays of an LED chip," says Dr Ing Gunnar Koether from the lighting and vision department of Volkswagen AG. "The challenge with the second concept," Koether points out, "is to achieve an homogeneous light pattern, without the limits between the arrays being visible."

If this problem can be cracked, though, a beam pattern even more adaptable than that provided by a moving screen should become achievable.

A world of innovative transmission solutions for a greener future

The innovation of new transmission and driveline technology for CO_2 reduction in automotive powertrains has never been more important than now.

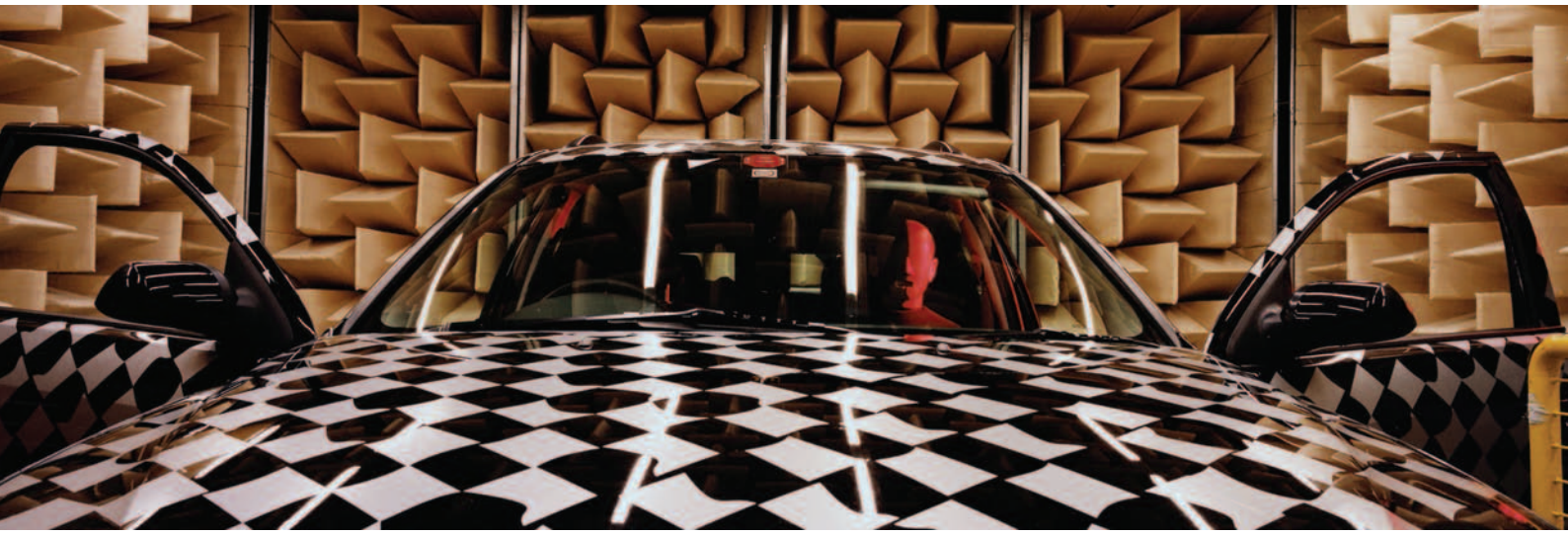
Drive System Design is dedicated to reducing environmental impact by providing high value, high quality innovative solutions to meet the modern demands of transmission and driveline systems for low and zero emission vehicles.

- Specialists in Hybrid Automated Manual Transmissions
- Specialists in Multi-Speed Electric Vehicle Transmissions
- Efficiency Optimisation of Existing Drivelines
- Design of New High Efficiency Transmissions
- Low Noise Gear Design Technology
- Hybrid and EV Transmission Controls and Calibration

Our **Expertise** Drives **Innovation**

DRIVE SYSTEM DESIGN

T: +44 (0)1926 678310
info@drivesystemdesign.com
www.drivesystemdesign.com



Making a big noise

NVH materials are becoming more important as comfort moves up the design agenda. Lou Reade reports

You'd think that the development of quieter engines – such as those seen in hybrid or electric vehicles – would make life easier for the acoustic engineer. If anything, the opposite is true, because suddenly drivers can hear a new range of annoying squeaks, rattles and vibrations.

"Many of these noises were previously hidden by the noise of the engine," says Ivan Mini, global market manager for automotive interiors and safety components at Dow Corning. "On the one hand, we're trying to damp vibrations from the engine. But we're also looking to identify sources of noise in the car interior."

The ever increasing need for comfort, especially on high-range cars, means these noises must be eliminated. There are many reasons for interior noise, he points out, with one of the main culprits being when two different materials rub together. A variety of plastics – including some recycled materials – are finding more and more use in car interiors. If they are in contact with a different material, whether it is a metal or another plastic, this can set up 'micro vibrations' – causing unwanted squeaks. More annoyingly, noises like this can be amplified by other components, such as door panels.

The noises can be prevented in a number of ways: elastomeric materials – for use as gaskets or as adhesives – allow parts to flex and absorb vibrations; and various additives and dry lubricants can ensure that parts rub together, without generating noise.

Dow Corning can run tests on components to see whether two materials will make a noise when rubbed together. These tests can be repeated with different materials formulations, such as with and without a lubricant additive. The test helps to match materials, ensuring that those with the correct mechanical properties, for example, will not generate unwanted noise.

While most car design teams can call on acoustic specialists, Mini feels that NVH issues do not merit as much attention as mechanical or aesthetic design, but thinks this is beginning to change. "Designers are getting more conscious of it, because of the importance of comfort in the car," he states.

Attention to NVH can also deliver design flexibility, he says: for example, if the sliding mechanism for a seat uses a dry lubricant, rather than grease, there is no need to have a cover over it – saving one component. The company is also considering extending the concept of its 'NVH kit', which contains seven products in a 'briefcase'. The products, such as sealant and various dry lubricants, have been used by designers to develop prototype parts for car interiors.

"We're now planning something similar for other areas of the car, such as the engine and transmission," he adds. The proposed new kit would probably include some elastomeric materials

Sophisticated electronics, complimentary materials and semi anechoic chambers are tools in the NVH challenge

and heavy-duty lubricants. Reducing weight is critical for all parts of the car: with new European penalties ready to be introduced next year, punishing cars with higher emissions, any weight reduction will automatically lead to a cost reduction. In fact, Rieter Automotive says that each 1kg saved would equate to a E4.2 saving in penalties.

Immediate savings

"Each kilo weight saving with lightweight products will mean immediate savings of penalties for the whole vehicle fleet, which has an enormous value for the OEMs," comments Maurizio Mantovani, head of comfort functions at Rieter's European acoustics business group.

He says there is a strong push to reduce the weight of NVH materials, in order to save fuel and cut emissions. An example is its Ultralight family of products, which are used for carpet systems, inner dashes, parcel shelves and trunk trim. Rieter claims that it can cut the weight of an NVH system by 40%. In the Mini Countryman, a complete thermo-acoustic engine encapsulation system has lowered emissions and cut fuel consumption.

One way in which Rieter plans to develop optimised designs of NVH components is by using an in-house finite element analysis (FEA) program. The damping simulation procedure, called Silver, was presented at the recent Society of Automotive Engineers congress and is fully integrated in Nastran. "The procedure makes it possible to design the optimal damping layout, with respect to panel mobility targets, while taking into account the presence of the insulation part on body panels," says the company.

All change

For Alain Guillaume, engineering manager at Trelleborg Automotive, NVH materials will have to work "even harder" as cars become better insulated against noise and vibration. "Third-order frequencies, or parasitic noise, become more evident to the driver and passenger," he says.

"Electric vehicles should push this demand further, leading to an increasing use of active solutions – noise cancellation and not just damping," is his contention.

Guillaume says that NVH components are becoming smaller and lighter for a number of reasons. One is the need for increased fuel efficiency, meaning that more NVH components are using plastics and composites: higher performance vehicles are increasingly using fibre-reinforced rubber, for example, which helps to enhance strength and durability. At the same time, the trend towards smaller cars means that dampers must fit into a smaller space. Designers are having to react to new types of car as well.

"Hybrid technologies require mounting solutions that can switch between two states – an engine undergoing combustion (high vibration) and electric power mode (low vibration)," he points out.

Farther ahead, other emerging technologies are likely to pose new design headaches. "The development of fuel cell technologies creates new challenges," concludes Guillaume. "The component's lighter structure means increased vibration, as NVH switches focus to chassis, rather than powertrain, solutions."

So, as cars get quieter and lighter, designers are faced with a new set of challenges. When electric or fuel cell-driven cars become mainstream, the cockpit will be almost devoid of engine noise. This means that designers of car interiors – and developers of NVH materials – will have to change their focus, if they are to banish unwanted noise from the cockpit.

The only alternative, it seems, would be to turn the radio up that bit louder.

www.microchip.com/automotive

Microchip Technology - Accelerating distributed intelligence in tomorrow's vehicle

Microchip Technology has many years of experience in delivering embedded solutions to automotive customers globally, and has a broad portfolio of products, development tools and design support. Microchip offers creative solutions to the automotive system suppliers that are helping the automotive OEM deliver vehicles that have reduced fuel consumption with lower emissions and deliver a safer, more comfortable driving experience for the driver.

Microchip's commitment to the automotive electronics market is demonstrated over the years by providing timely, quality solutions that lower total system cost. It doesn't stop with just innovative products. Leadership in manufacturing enables dependable delivery so that Microchip's customers have product when they need it.

The sustained success in automotive electronics for Microchip can be attributed to its focus on, both emerging and well established applications, where solutions from Microchip add value. Our customers can count on solutions which enable the customer's ability to develop electronic modules that reduce the environmental impact in their quest to enhance fuel efficiency, reduce emissions and support sustainability.

Flash Microcontrollers and Digital Signal Controllers

- Broad portfolio of 8-, 16- and 32-bit PIC® microcontrollers, 16-bit dsPIC® digital signal controllers
- From small, efficient, nanoWatt eXtreme Low Power microcontrollers to large, multi-function microcontrollers
- Wide array of digital and analog peripheral functions
- Easy migration paths
- Supports operations up to 150ºC ambient temperature environment
- Unified development environment
- Variety of package options from small, 6-pin leadless packages to 144-pin TQFP

Serial EEPROMs

- Fast bus rates
- High endurance
- Low power consumption
- Small footprints
- Triple Test Flow – results in near zero infant mortality and outstanding data retention
- SEEVAL™ 32 Serial EEPROM Designer's Kit
- Total Endurance™ Software Model
- Supports operations up to 150ºC ambient temperature environment

Analog & Interface ICs

- Ultra-low power
- Non-volatile memory trimming
- Thermal management
- Power management
- Supports operations up to 150ºC ambient temperature environment
- Signal conditioning
- Linear, mixed signal and interface
- In-vehicle network interface solutions
- CAN transceivers and stand-alone controllers with SPI
- LIN transceivers with integrated voltage regulators

mTouch™ Sensing Solutions

Microchip's mTouch Sensing Solutions provide an easy method for designers to add touch sensing utilizing PIC microcontrollers without the cost of fee based licensing and royalty agreements. With both capacitive and inductive touch sensing solution being available from Microchip Technology, the automotive embedded system designer has the flexibility to select the right touch technology to satisfy their application performance and cost requirements.

Microchip's broad product portfolio coupled with applications support and reference designs enable the automotive system designer to deliver cost effective solutions in an environment where fast time to market is essential. Microchip's continuous investments toward advancing semiconductor solutions enable a range of cost effective solutions. For example, LED lighting, motor control, mTouch sensing and battery monitoring are poised for further expansion. Microchip has local offices throughout Europe.

For more information, visit

www.microchip.com/automotive or contact our European Automotive Product Marketing Manager Johann Stelzer on + 49 89 627 1441 22 or johann.stelzer@microchip.com

MICROCHIP

European Headquarters

Microchip Technology
Microchip House, 720 Wharfedale Road
IQ Winnersh, Wokingham
RG41 5TP.
United Kingdom
Tel: +44 118 921 5900
Email: euro.enquiry@microchip.com

Accelerating Distributed Intelligence in Tomorrow's Vehicle

With many years of experience in delivering embedded solutions to automotive customers globally, the broad portfolio of products, development tools and design support from Microchip Technology enable automotive system suppliers to develop creative solutions. These solutions are helping automotive OEMs deliver vehicles with reduced fuel consumption, lower emissions and a safer, more comfortable experience for the driver.

Microchip's commitment to the automotive electronics market is demonstrated by providing timely, quality solutions that lower total system cost. It does not stop with just innovative products. Microchip's leadership in manufacturing enables dependable delivery so that our customers have product when they need it.

Flash Microcontrollers and Digital Signal Controllers

- Broad portfolio of 8-, 16- and 32-bit Microcontrollers, 16-bit Digital Signal Controllers
- eXtreme Low Power, High Performance

Analog & Interface ICs

- Ultra-low power analog
- LIN Solutions

Serial EEPROMs

- Fast bus rates and high endurance

Automotive Qualification

- AEC-Q100 Grade 1 and Grade 0 (150°C)
- Meeting OEMs' robustness and emissions standards

Reference Designs to Accelerate Time to Market

- HID Lighting
- LED Lighting for exterior and interior, e.g. DRL, dome light, ambient light
- BLDC Motor Control e.g. pumps, fans, actuators
- mTouch™ Human Interface e.g. HVAC, Radio/Infotainment
- DC/DC Power Supply, e.g. start-stop systems
- CAN/LIN Solutions, e.g. smart actuators and switches

microchip DIRECT
www.microchipdirect.com

www.microchip.com

MICROCHIP

Technology on Parade

Hella's LED system offers distinctive styling and flexible lighting for the new Audi A6.

LEDs' drive styling

Steffen Pietzonka, vice president of marketing for Hella's automotive group, says that styling is the current main driver for OEMs selecting an LED headlamp option. "Our LED system clearly contributes to the distinctive styling that differentiates the Audi A6 from other luxury cars."

While styling is important now, Pietzonka sees a future where fuel economy and efficiency are increasingly significant reasons for selecting LED lighting.

Expect more from Hella in the near future. "For model years 2013 through 2016, we have requests to supply LED headlamps to 40 different models," he states.

While LED lighting is currently an option for high-end luxury cars, he notes that half of these current requests are in midrange and lower segments. LEDs are expanding beyond luxury cars.

Cost is still an issue. What might drive this down? "We need standards to reduce the individual piece cost of individual LEDs," he comments. Such standards could include driver circuits, as well as shapes of individual LEDs. This should not cause issues unduly in creating unique, brand-specific shapes for headlamps or other lighting features, he adds.

Scratch resistance researched

Engineers from Hyundai Motors' polymeric materials research team have been investigating the contribution of each major component in polypropylene (PP) compounds to the scratch phenomenon and established general guidelines to achieve a desirable level of scratch resistance in designing PP compounds.

The Hyundai researchers compared the scratch resistances of four different homo PPs and four different PP block copolymers with varying MFR (melt flow rate).

Among homo PP, PP block copolymer and HIPP with a similar level of MFR, the order of scratch resistance was: homo PP, HIPP, block PP. Even though homo PP exhibits a superior scratch resistance than the other types of PPs, its usage for automotive parts has been decreasing, due to its poor impact/stiffness balance. Meanwhile, usage of HIPP has been increasing, due to the strong impact/stiffness balance and good scratch resistance. PP block copolymer can provide effective impact strength, but scratch resistance is not as solid as other PPs.

It is also important to choose appropriate filler and impact modifier rubber systems. The majority of automotive-application PPs require adding certain amounts of fillers and rubbers to meet all market requirements. However, adding fillers and rubbers in PP hurts the scratch resistance; the material designer should try to use minimal amounts of fillers and rubbers. Using a smaller size filler, a more compatible coated filler and a high molecular weight rubber, replacing some portion of talc with wollastonite, should be helpful in minimising the reduction of scratch resistance.

When the researchers compared the scratch resistance of PPs with different fillers, the order of scratch resistance was: coated talc, wollastonite, uncoated talc. The talc coated with calcium carbonate (CaCo3) gives better dispersion and stronger bonding with PP matrix than other inorganic fillers and less

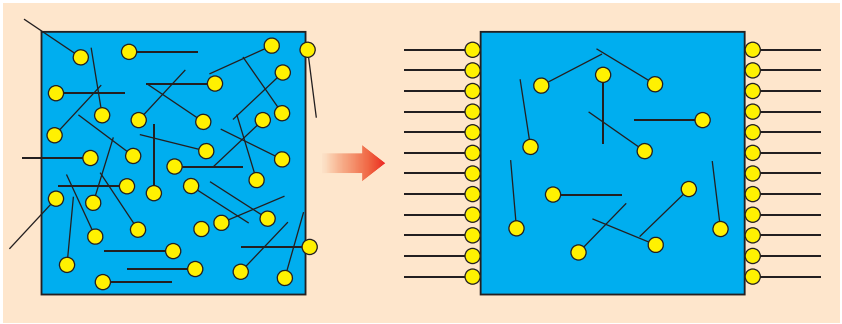


Illustration showing the migration of slip agents to the surface

debonding of talc particles during scratch. As PP filled with coated talc has good impact strength, it needs a lesser amount of rubber impact modifiers, which also helps improve the overall scratch resistance.

Likewise, using the appropriate slip agent additives is important. Migratory-type additives such as erucamide can provide good scratch resistance at lower cost, but surface blooming can be an issue, if it is used too much. Slip agents having good compatibility with PP and high molecular weight are desirable.

Another type of slip agent is 'nonmigratory', the most commonly used for PP being polysiloxane. A polysiloxane slip agent does not quickly migrate to the surface, due to its high molecular weight, and gives fewer problems in surface blooming and tackiness, compared to migratory types. Since polysiloxane tends to be absorbed in talc and coat talc particles, it gives excellent scratch resistance.

Because nonmigratory slip agents generally provide a great improvement in scratch resistance, but are more expensive, compared to migratory additives, sometimes migratory and nonmigratory additives are used together. Since adding a nonmigratory additive can significantly affect the material mechanical properties, engineers should carefully choose the additive type and dosage amount (see diagram opposite).

This article is based on SAE technical paper 2011-01-0461, written by Won-Jong Noh, Jung-Gyun Noh, Dae-Sik Kim, and Suk-Hwan Kim, polymeric materials research team, Hyundai Motor Co.

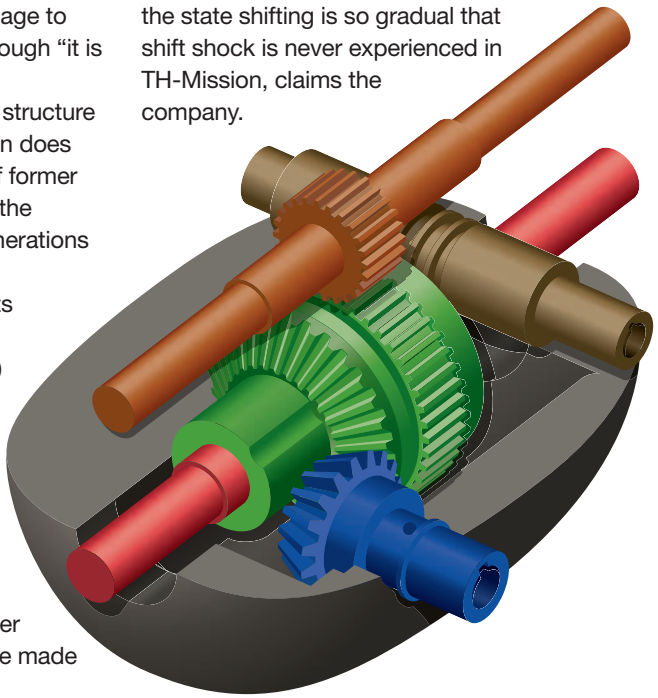
Fifth-generation transmission

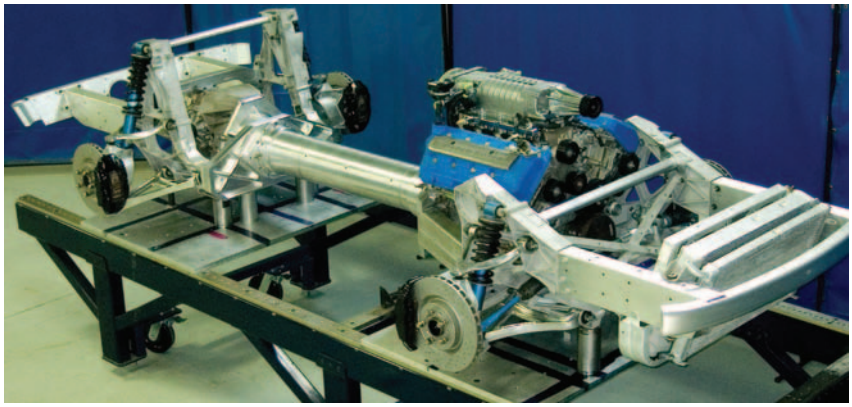
When THT Co. refers to its TH-Mission as 'fifth-generation technology', it is paying homage to what came before it, even though "it is superior to even the latest transmission, in terms of the structure and performance. TH-Mission does not only inherit all the pros of former generations, but also solves the problems that the former generations had".

The company says that its continuously gear-meshed variable transmission (CGVT) technology that makes up TH-Mission is "extremely simple in structure" and requires no advanced manufacturing technology. Also, its gears are always meshed, so loss from power delivery is minimised for better performance, allowing it to be made very small and light. In fact, THT says that TH-Mission "can be small as a thumb and indefinitely large, as long as building technology allows, so it can apply to all kinds of driving machines".

While the device may look unassuming, THT says the mechanism that controls speed and torque output "is not as simple as the structure. Basically, the main motor supplies primary power to the whole mission and the control motor decides how to use the power".

THT describes the operation of TH-Mission as being "characterised by moving smoothly from one extreme state to another" or, essentially, gear shifting. Those two extreme states can be compared to the lowest and highest gear of other transmissions; the lowest gear corresponds to the 'torque-oriented' state and the highest gear to the 'speed-oriented' state. THT says that it refers to the conditions as 'states', instead of 'gears', because TH-Mission is not designed with multiple numbers of gears to shift. Rather, the control motor functions so that, even though gears are always meshed, gradual shifting from torque- to speed-oriented state is possible. Moreover, the state shifting is so gradual that shift shock is never experienced in TH-Mission, claims the company.





The proof-of-concept chassis from Theodore & Associates is made up of four cast-aluminum suspension nodes and aluminum extrusions. Powertrain and susension is from the Ford GT supercharged 5.4L engine and six-speed transaxle, and the 8-in (203-mm) tubular backbone doubles as the torque tube.

Torque-oriented state provides the highest output torque and lowest speed, very similar to the first gear of other transmissions. But, according to THT, torque-oriented state is unique, in that it maximises output torque close to 100% and minimises the speed almost to zero. In other words, TH-Mission converts power from the main power source almost completely to torque, which is beneficial, since it requires a great amount of torque for a vehicle to overcome static friction that occurs when trying to move from standstill.

In terms of its make-up, in the torque-oriented state the rotation of the ring gear and the carrier (pinion gear revolution) is subtracted to decrease the sun gear (output) rotation.

By contrast, speed-oriented state provides the highest output speed and the lowest torque. As a vehicle starts moving, static friction disappears and dynamic friction becomes the only force to overcome, which is much less than the static friction. Therefore, the output torque starts to be wasted.

Although other transmissions are capable of shifting to higher gears as the dynamic friction decreases, output torque is still wasted to some extent, because the ratio gap between the gears is so large that it is expressed as shift shock. THT says that TH-Mission "gradually converts the output torque to speed, as if it has thousands of gears to shift". As a result, TH-Mission goes to maximum speed "with minimum waste of energy". In the speed-oriented state, the rotation of the ring gear and carrier is added to increase the sun gear rotation.

The engine (or motor) braking system of TH-Mission is controlled electrically. Releasing the accelerator and stepping on the brake switches from speed- to torque-oriented state by both stopping the main power source and gradually increasing the carrier rotation to predetermined rotation rate. As the carrier rotation rate increases, the sun gear rotation rate exponentially decreases; thus the speed also decreases. The stepping strength of the brake pedal determines how fast the rotation rate of the control motor increases to differentiate braking intensity. During deceleration, the sun gear run by inertia provides power to the mission, so the direction of power changes towards the input; as a result, the sun gear rotates the input gear that is connected to the main power source. Therefore, if the main power source is a motor, it becomes a generator during braking. Also, because braking shock increases the workload of the control motor, important for the braking system of TH-Mission, workload to the worm gear should be reduced. The bevel gear of TH-Mission takes the half of braking shock. In that way, the worm gear works more easily.

Flexible chassis design

Uni-Chassis from Theodore & Associates provides an alternative structure by connecting stressed front and rear powertrain/suspension structures to a rigid backbone, eliminating the frame (left).

Theodore believes Uni-Chassis has significant potential for specialty vehicle makers, along with coachbuilders and the aftermarket.

Because of the heavy use of extrusions and the six castings, tooling costs are lower than a typical spaceframe, according to Theodore: "Conservatively, we estimate 10% less, although one study indicates more. The real investment savings come when you apply Uni-Chassis to a family of vehicles. Wheelbase can be increased basically by increasing the length of the backbone extrusion and quill shaft (of course, front and rear structures need to be designed to handle the platform bandwidth), spreading investment costs among multiple vehicles."

Front, rear and offset impact loads are handled in much the same manner as conventional structures, with crush beams attached to the front and rear of the Uni-Chassis. And because most of the vehicle mass is carried by the Uni-Chassis in front and rear impacts, body impact loads are minimised—much like body-on-frame construction.

"One potential advantage is that Uni-Chassis decouples chassis and body crashworthiness requirements, such that the deceleration pulse can be 'tuned' by both the Uni-Chassis and the interaction of the body to the Uni-Chassis," Theodore explains. "On the other hand, the body structure must still be designed for side impact, rollover and restraint system loads, much like a pickup cab."

At the forefront of ground vehicle standards development.

Then and now.

The first engine oil viscosity standard and the introduction of engine horsepower ratings. The influence of motorcycle headlamps and rollover protective structures for tractors. A standard that defines electric-vehicle charging couplers and the creation of those to aid in the development of the Smart Grid.

For over 100 years, SAE International has played a critical role in the progress of the automobile and the ground vehicle industry.

And while the work of engineering today's vehicles may on the surface look very different given the complexity of technology and global markets, SAE International and its standards development program have essentially remained unchanged. It continues to provide a neutral forum for collaboration on common engineering challenges and the creation of standards, thereby helping industry reduce costs, increase productivity, improve market position, and advance new technologies.

Whether it is bringing standards for and from the United States market to the global table or serving as the world's center of expertise on Commercial Vehicle/ConAg standards, SAE International is uniquely positioned to provide innovative standards solutions—be they by consensus, consortia or harmonization—that offer industry, companies, and individuals opportunities to influence, grow, and prosper.

SAE International®

"The society dedicated to advancing mobility engineering worldwide"

Automotive Headquarters - 1.248.273.2455
www.sae.org

THE SHIFT TO

Both precious and rare earth metals are required for the manufacture of exhaust catalytic converters. Principally, the precious metals most used – platinum, palladium and rhodium – are needed for both the oxidation and reduction reactions required in a three-way catalytic converter to reduce the amount of toxic pollutants in gasoline exhaust gases. Current systems operate with a conversion rate of around 90%.

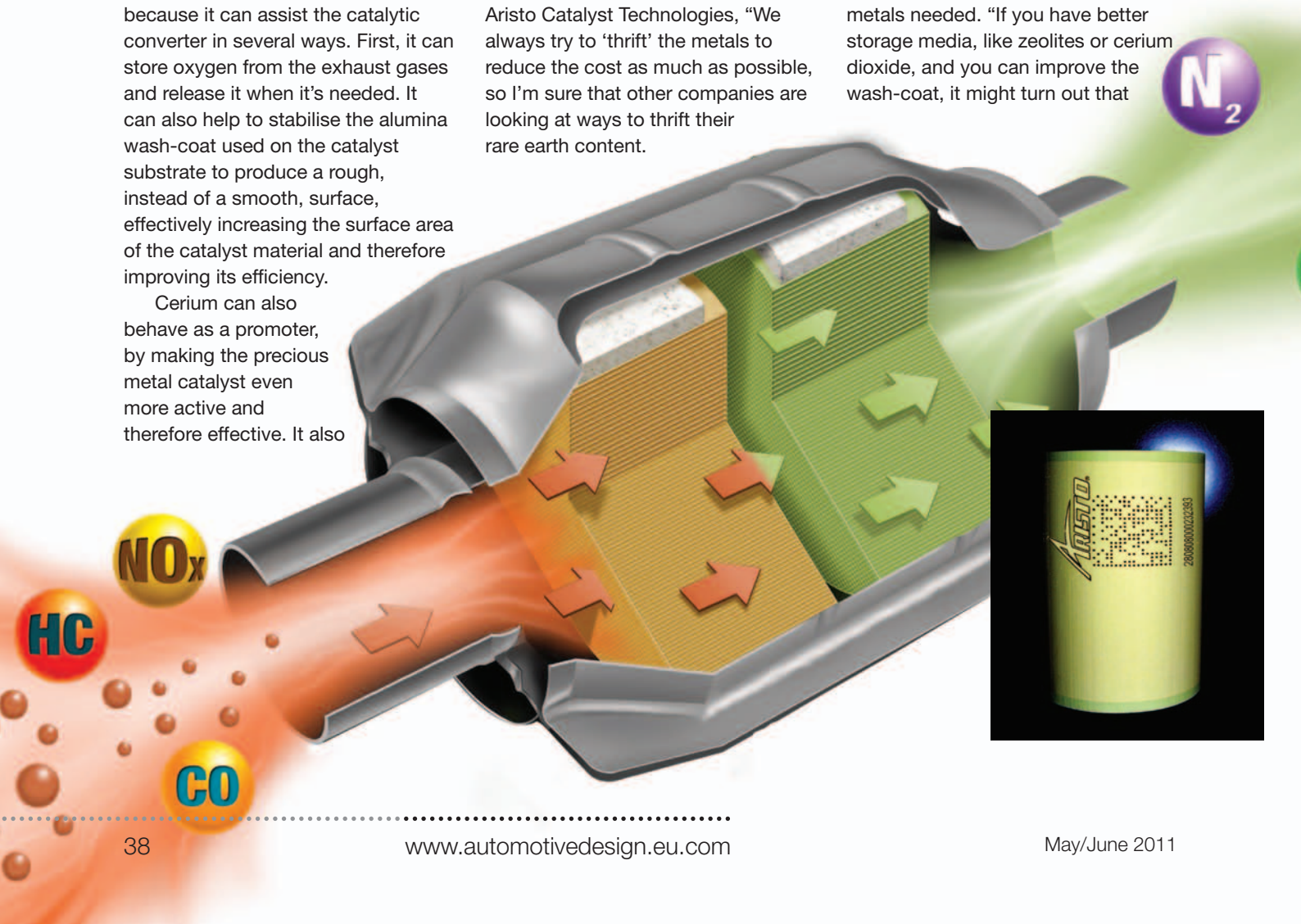
In addition to the precious metals, the rare earth metal cerium is the most widely used of its type, because it can assist the catalytic converter in several ways. First, it can store oxygen from the exhaust gases and release it when it's needed. It can also help to stabilise the alumina wash-coat used on the catalyst substrate to produce a rough, instead of a smooth, surface, effectively increasing the surface area of the catalyst material and therefore improving its efficiency.

Cerium can also behave as a promoter, by making the precious metal catalyst even more active and therefore effective. It also acts as a catalyst itself. Although cerium is more common than some other metals, it is not readily found in the kind of concentrations considered to be commercially exploitable, which means that the economically viable deposits are not always to be found in politically expedient or geographically convenient locations. Extracting the metal produces toxic waste that also needs careful disposal.

Manufacturers have a strong interest in finding more cost-effective alternatives. "What we can do is get smarter about how we use materials," says Bob McDowel of Aristo Catalyst Technologies, "We always try to 'thrift' the metals to reduce the cost as much as possible, so I'm sure that other companies are looking at ways to thrift their rare earth content.

"How you can do that in general is to be smarter in how you place it in the catalyst and in the formulation." That means finding ways to retain the durability requirements of the catalytic converter, while using 10 or 20% less cerium. "That thrifting process obviously gets more intense as the price goes up", states McDowel, "There's not a whole lot we can do, in terms of substitution of one rare earth for another."

At the same time, improving the wash-coat that contains the rare earth metals, so that it can store oxygen more effectively, could reduce the amount of precious metals needed. "If you have better storage media, like zeolites or cerium dioxide, and you can improve the wash-coat, it might turn out that



THRIFT

John Kendall reports on the challenge of reducing rare earth elements in exhaust catalysts

you can reduce the precious metals, while still having the same efficiency", suggests Frank Terres, exhaust aftertreatment engineering director for Tenneco's OE Emission Control Europe facility in Germany.

Cerium is already one of the least expensive rare earth metals. Bob McDowel from Aristo continues: "The alternatives are, change your regulations; make them easier, so that you don't need all those rare earth and precious metals, but that's not likely to happen.

"We're fairly far along the trail of thrifting and substituting cheaper materials for the rare earths, if we could. Again, the other alternative is to use more precious metals, but that's not cost effective either.

"People are looking at potentially just using cerium for the precious metal promotion activity, as opposed to the oxygen storage activity. There's a small start-up company looking into replacing the alumina wash-coat material with silicon dioxide. What they have not proven yet is, if they can substitute these silica fibres for the precious metal support – the alumina wash-coat we've been using for 35 years now – you can get a more effective catalyst, with very little use of the precious metal, because of the 'nano' technology."

"Typically, the way the industry responds to increasing prices is to find ways to reduce their usage, not cut their usage to zero, says Dr David Belton, GM Fellow for Emission Controls. "I think that is probably the most likely response we will have for some time. Sometimes, we can make the catalytic converter slightly bigger and, by making it bigger, we can use slightly less precious metals.

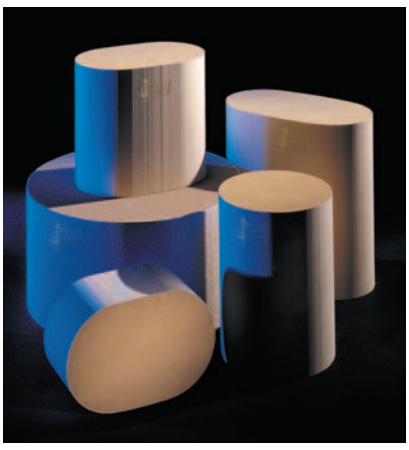
"In some cases, there are other technologies or devices we can use, but right now those other devices haven't proved to be cost effective, because the price of, say, palladium and rhodium hasn't gone high enough yet to drive us to use them."

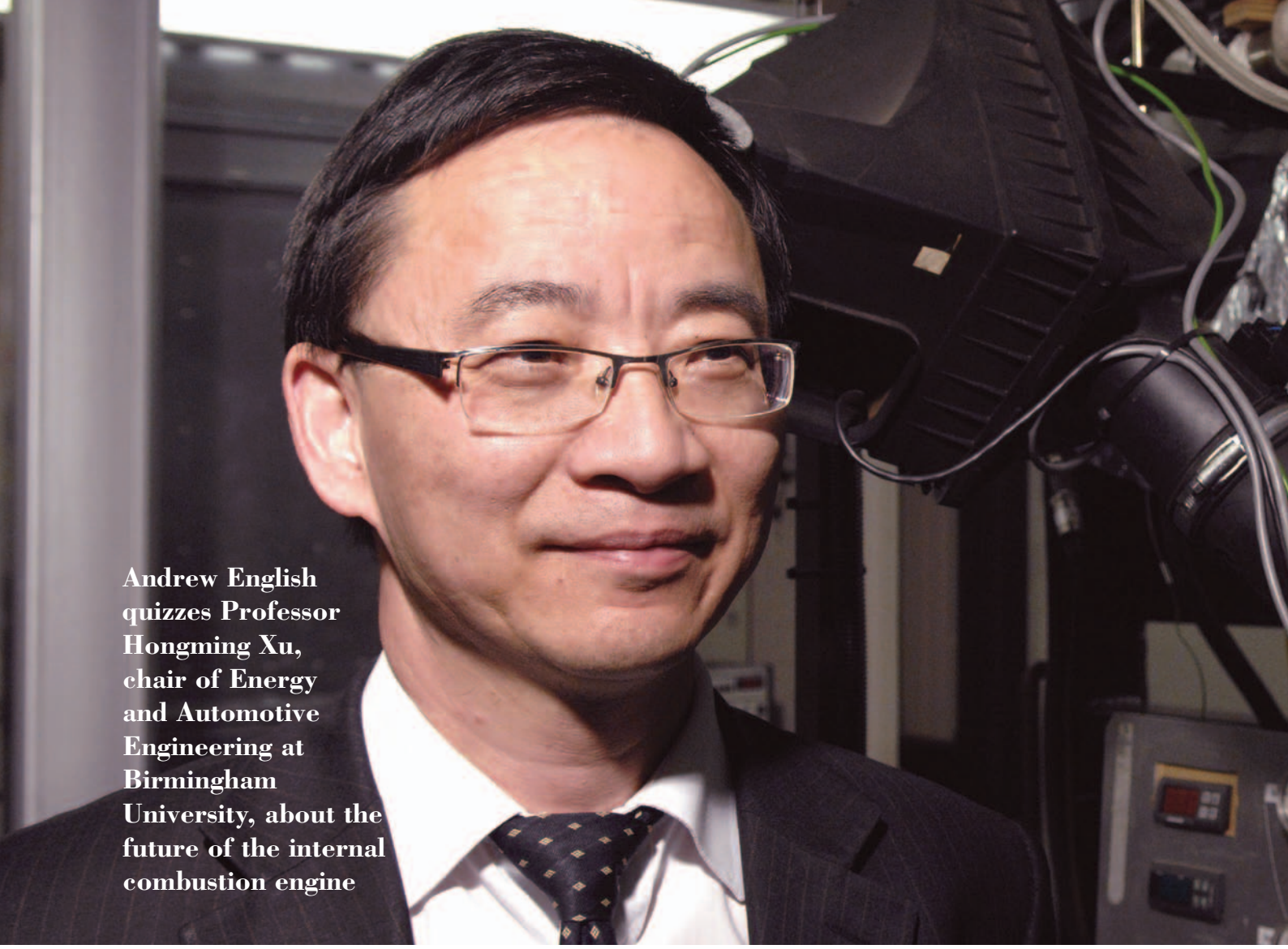
Belton gives the example of an auxiliary pump, designed to pump fresh air into the engine. "Called secondary air injection," he continues, "that enables the catalyst to become hot faster and so it replaces precious metals in the catalyst. The price is about €70 per vehicle and right now the precious metal prices don't really dictate using that device yet."

GM announced last year that it was investigating the use of Perovskite in catalytic converters. Is this material a potential replacement for precious metals? "Perovskite materials are just another in the continuing evolution of catalyst technology improvement," says Belton. Like the rare earth metals, their role is to improve the effectiveness of the catalyst. "I wouldn't say they are particularly a breakthrough, they're more like an incremental improvement. Those materials help the more expensive precious metals remain as very small individual particles on the catalyst, as opposed to coming together in larger sized particles. Since only the precious metals on the outside of the particle are effective for catalysis, then a bunch of small particles are a lot better than a few large particles."

With the emissions focus shifting away from toxic emissions towards carbon dioxide emissions reduction, gasoline engine technology will be drawn more towards lean burn systems. "That actually has a tendency to drive the industry away from platinum and rhodium to some extent and towards other materials," suggests Belton. "So it could turn out to be true, depending on how manufacturers solve that CO_2 problem, that CO_2 regulations could actually decrease the pressure on the precious metals market. If you go to a true lean-burn gasoline system, then you won't have conventional three-way catalysts. You'll have a system that more closely mimics the diesel after-treatment system."

Latest catalyst bricks employ minimum levels of coating





Andrew English quizzes Professor Hongming Xu, chair of Energy and Automotive Engineering at Birmingham University, about the future of the internal combustion engine

Smarter combustion

Homogenous Charge Combustion Ignition (HCCI)? You'd be forgiven for thinking it has turned into the great South Sea Bubble of the automotive industry. From rave reviews at the beginning of the century, this sparkless technique of compressing well mixed fuel/air mixtures, until they ignite, has almost disappeared in recent years. To the extent that, when BMW recently unveiled its next generation of three-, four- and six-cylinder engines, HCCI wasn't even mentioned.

Professor Hongming Xu, chair of Energy and Automotive Engineering at Birmingham University, is the man most likely to explain what has happened to HCCI.

So, is HCCI a busted flush? Xu cautiously agrees that the heat has dropped in research. "From my first job at JLR in 2000, I was working on this technology and also at Birmingham University. The most crucial time for the research was between 2005 and 2007." He points to more than 200 publications of original research in SAE papers from that period. "Now publications have fallen off to a third of that," he says, "and, in my opinion, there is very little new stuff coming out at the present."

What's gone wrong? "In the early years of research, the car industry was overwhelmed with advantages, but now the disadvantages have been fully exposed," he points out.

He says the production realities have now sunk in, such as the limited operating region where an engine can be run in HCCI mode and the fact that the engine has to be turbocharged or supercharged, in order to extend that operating region.

"The benefits of HCCI are greater in a gasoline engine, where you gain fuel economy," says Xu. "A diesel doesn't benefit from much greater economy, but HCCI does reduce emissions of oxides of nitrogen and particulates simultaneously."

He states that the economy benefits in petrol engines accrue mainly from the throttle-less operation, more so than the precise control of fast combustion. Combustion efficiency is lower in a HCCI engine, because the combustion temperature is lower."

"There were claims of between 20 and 30% economy gains," he says, "but that was only at certain operating periods. Those gains were nearer to

Question time

four per cent at a vehicle level, although the adoption of turbocharging can make the operating window larger and thus the gain bigger. “Up to 10%,” he says before cautioning, “you have to be very careful with the figures.” This is because advances in other areas such as cam profile switching (CPS) techniques will have contributed their own fuel savings. “You can’t give all the credit to HCCI,” he says.

It was cost that also caused the industry to rethink its HCCI plans. Xu reckons the on-costs of CPS to be about €350 an engine unit, depending on the numbers of cylinders.

Then there’s a reliability factor and the effects of early detonation on the cylinder block. Mercedes Benz has only just sorted the problems in its ‘Diesotto’ F700 1.8-litre, four-cylinder HCCI engine, first shown in Frankfurt in 2007. “We went silent on the project, because we were having problems,” said Professor Herbert Kohler (head of ‘e-drive & Future Mobility’, chief environmental officer, Daimler AG) earlier this year. But we now have a totally different design of crankcase, which is highly modified from standard. Now we need to work on the question of costs and results.”

He is confident that the Diesotto system could be on the market in as little as two years, although the modified crankcases would need a new generation of engines that dictates when they could be introduced. “It all depends when we modify the crankcase,” he says. “This is not an easy or a cheap investment.”

So does Xu think that it’s all over for HCCI? Absolutely not. “There is continuous research in this area, although in smaller scales.” He offers an example of recent progress. “A joint research group of Tsinghua University and Chery in China has just demonstrated they can now run a HCCI engine in a real passenger car model, with attractive fuel economy benefit, and this appears to be a step ahead among very few others towards the practical application of HCCI.

“The benefits of HCCI are greater in a gasoline engine, where you gain much greater fuel economy,”

“HCCI is now a generic name covering all manner of technologies involving premixed compression ignition combustion,” he says. “The endless name list ranges from PCCI [Premixed Charge Combustion Ignition, used in diesel engines where multiple injections of fuel control the release of combustion heat and therefore soot] and PPCCI [Partially Premixed Charge Combustion Ignition], they are all derivatives of HCCI technology.”

And as modern petrol engines start to sprout turbochargers, variable cam phasing and direct fuel injection to meet forthcoming emissions legislation, HCCI is looking increasingly possible and feasible. Another example is the complex, fragile and expensive sensors required to monitor the combustion process in each cylinder on HCCI engines. Tomohiko Kawanabe, Honda’s R&D director, recently told us that, as new engines are likely to require these sensors merely to meet forthcoming emissions standards, so HCCI, which his company is still working on, would be even more viable.

With HCCI derivatives, we have new ways of continuing the technology and people are working on it. It’s difficult technology, but the benefits are clear.”

In fact, Xu goes even further, predicting a new smart type of injector, similar in operation to an ink-jet printer, which could be used to control minutely the combustion process. He suggests that, in future, internal combustion engines should have both port and direct fuel injection. “We are already working on this,” he says. “Just imagine going to a fuel pump and filling up, using a coaxial fuel line with diesel, gasoline, maybe biofuel, or maybe some other type of fuel property modifier. The label would be ‘Hydrocarbon Fuel’; you wouldn’t have to know what it is, but the engine would identify it and burn it in the most efficient way, according to the operating conditions. It’s my dream and hopefully I will see it before I am finished with this business.”

Whether we will need such multifuel engines capable of burning fuels across a wide range of temperatures, speeds and loads, is a moot point. Hybridisation and the development of smart continuously variable transmissions mean engines wouldn’t have to deliver that sort of flexibility and could work at an almost constant speed and load. This seems unlikely, however and a much more credible future is where both poles of development continue and that includes HCCI and its derivatives.

“For a long period in the future, research on the internal combustion engine will continue,” says Xu. You can take that to the bank.

Peter Horbury, vice president design
Volvo Car Corporation

Pedals are fixed and everything else can adjust accordingly, goes the popular consensus. Here, Peter Horbury challenges that thinking

"To me, we've taken it for granted for too long that pedals are fixed and everything else can adjust. "On the Ford Flex, for example, there's a door-mounted switch that can bring the pedals closer or farther away, and that's the final bit of the equation of how you can sit safely and drive a car.

"It's a safety issue – how close do you want to sit in front of that explosive device in the steering wheel? Bringing the pedals back allows smaller people to sit at arms' length and operate the car, whereas, if the pedals are well underneath the footwell for a six-footer, a small woman has to bring herself farther and farther forward, and then look where the steering wheel is, in relationship to her position. To me, that's an important development for the future."

Horbury, who was executive director of design for Ford in the USA when the Flex was styled, reveals that Volvo is in the "early days" of talking with suppliers about adjustable pedal boxes, before confirming that Volvo is "considering" the technology.

"It's the last chink in getting the driving position set up safely and comfortably, whilst also being in command of the car. That's positive in itself – to feel that you are looking down on the road with a clear view. Adjustable pedals are a simple remedy to create the perfect driving position every time for everyone."

"It's a safety issue – how close do you want to sit in front of that explosive device in the steering wheel?"

Horbury reminds us that Volvo's 200I Safety Concept Car (SCC) "was based entirely on putting the driver in the perfect position, and that included the pedals, the centre console, the gearshift, the see-through 'A' pillars and the seat height, so that everyone saw the same view from the driver seat.

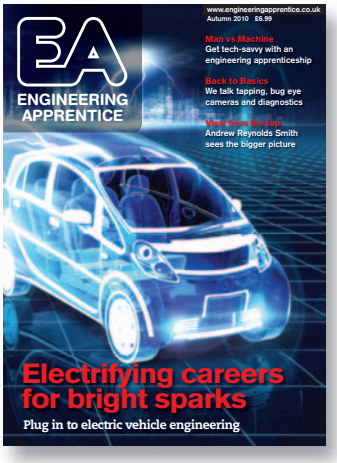
He also predicts that electric vehicles (EVs) will present designers with their own unique challenges. "EVs with large battery packs under the floor mean moving the seats outwards. But then the occupant's head is up against the cant rail, so that has to be moved out and upwards. The size of the battery pack is dictating the degree of the angle on the side glass.

"And as the bonnet moves up for pedestrian protection, the driver has to see across it, so then the seat moves, which means the front header moves up to comply with head impact criteria – and that means the windscreen becomes more upright. But, if you move the base of the windscreen forward, that's where the pedestrian's head will impact. It's a knock-on effect."

Inspired by innovation

findlaymedia

www.findlay.co.uk



Passionate about engineering

Photo: Rinspeed

The automobile future
drives with plastic!

We can only make guesses about the automobiles of tomorrow. But one thing is for sure: Their development will be influenced decisively by high-performance engineering plastics. Whether this concerns novel drive concepts, production processes or components, Ticona contributes valuable know-how and innovative products - as in the field of electric-powered mobility where Ticona delivers innovative solutions with high-performance plastics. Sandwich boards made from **Celstran® LFT** ensure greater stability and lower weight in battery support structures in automobiles. Connectors are already one product for the liquid crystal polymer **Vectra® LCP** which is also used in high-voltage applications, in lighting and as an insulator for actuators or motors. The ultimate material for electrical components is **Fortron® PPS** in pumps for coolants, in fans as well as in coil carriers and relays. **Hostaform® POM** with the low-emission XAP grades is excellent for use in automobile interiors. Electromechanical components in the on-board power supply have long been a specialty of **Celanex® PBT.** And especially light battery separators can be achieved with the ultrahigh molecular weight polyethylene **GUR® UHMW-PE.**

What idea do you want to realize? We look forward to shaping the future with you!

High-performance polymers with perfect profiles

- Lower weight with greater resilience
- Low-emissive in automobile interiors
- UV resistance for visible moldings, resistance against weathering
- Excellent sliding properties and high continuous service temperatures

Your partner for high-performance polymers:

TiconaCommunicationsEurope@ticona.de · www.ticona.com

Ticona
Performance Driven Solutions™