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VALVE CONTROLS INFINITE POSSIBILITIES

ROGER STONE, CAMCON AUTOMOTIVE
TECHNICAL DIRECTOR





Where All the Pieces Fall Into Place

Let's face it; driveline design can be a real brainteaser. Reduced emissions. Improved fuel economy. Enhanced vehicle performance. Getting all the pieces to fit is challenging—especially when you can't see the whole picture. That's why you need one more piece to solve the driveline puzzle.

Introducing DrivelineNEWS.com—a single, all-encompassing website exclusively dedicated to driveline topics for both on- and off-road vehicles. Log on for the latest news, market intelligence, technical innovations and hardware animations to help you find solutions and move your business forward.

It takes ingenuity and persistence to succeed in today's driveline market.

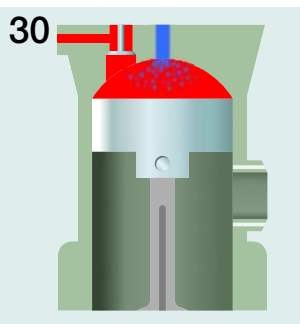
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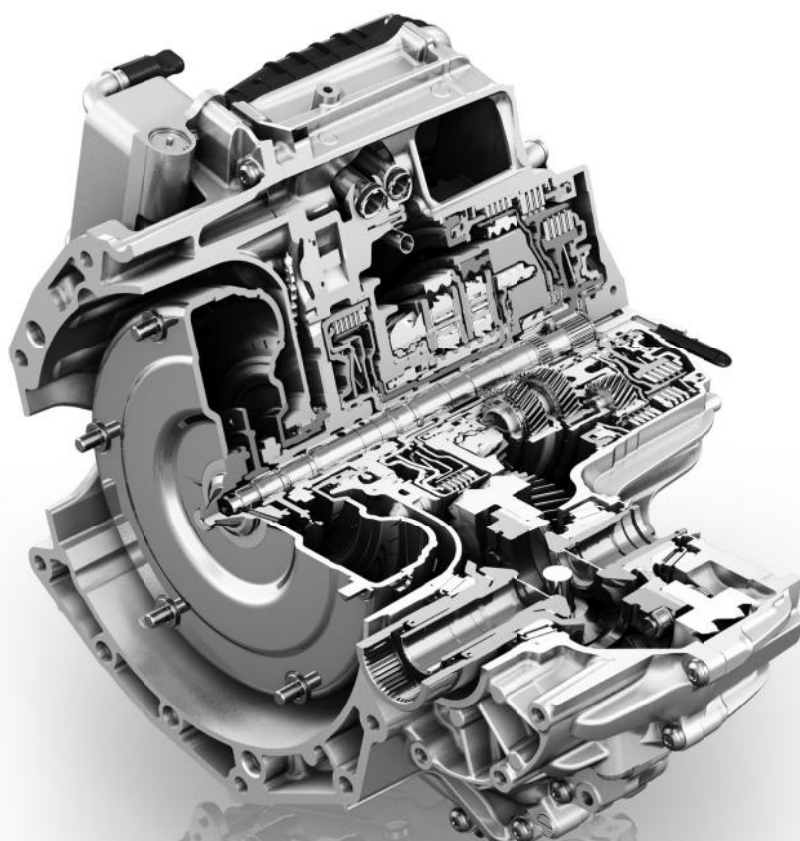
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MOTION AND MOBILITY



* Compared with today's standard 6-speed automatic transmissions in front-mounted transverse engines

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Ingenious solutions



One aspect of the motor industry that I never fail to marvel at is the sheer ingenuity of the individuals involved in the design, engineering and manufacturing of cars, trucks, vans and buses.

Take this issue as an example: Bernie Rosenthal's team at Reaction Design has developed a software programme to predict

engine knock in a virtual world (page 6), making the engine designer's life easier, especially those charged with developing the complex algorithms embedded in ignition, injection and timing strategies.

Or there's the lead story on Camcon Automotives development of an infinitely variable valve control system, enabled by expanding on a technology from outside the automotive industry – the result of a genuine 'What if?' moment from Camcons' boffins that could be a game-changer for engine design as significant as Peugeot's double overhead cam in 1912 or, nearer in time, Fiat's development of common rail diesel systems eight decades later.

Then there are technologies that are ahead of their time, hobbled by the lack of materials or the subtle control that micro chips bring, waiting in the wings to be revived - dual clutch transmissions is a classic example. Or, like the story in the last issue on the compressed air-assisted Peugeot engine or, as Andrew English reports on page 30, engines running on cryogenic air. The Liquid Air Car Company of Boston, USA, had such a powered car 111 years ago. Only time will tell if the moment has now come. But, with increasing demands being made on emissions, then the industry, rightly, is leaving no stone, no matter how improbable, unturned to keep us all mobile.

Ian Adcock, Editor in Chief

Smaller engines and increased turbo boost put the 'knock' back into motoring

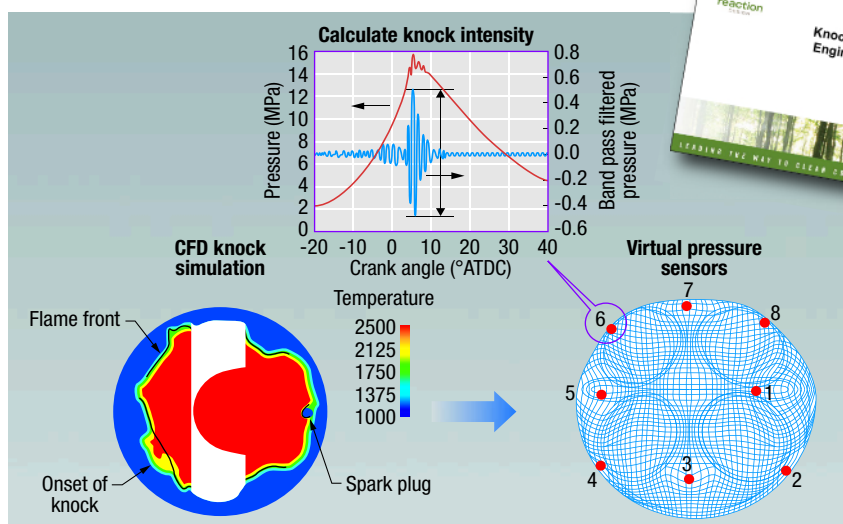
Engine knock is becoming more prevalent, says Bernie Rosenthal, CEO Reaction Design, as manufacturers downsize engines and increase turbo boost. The problem is further exacerbated with the increasing use of blended bio fuels and the emergence of dual fuel engines that run on a combination of diesel and natural gas.

Best known for its work in modelling fuels and combustion simulation with the Model Fuels Consortium (MFC), Reaction Design has used this know-how to intelligently reduce the master models' 4,500 or so species down to 400-500 for the purposes of its knock predictor – "...and even that is 4-5 times more than what you could handle in a common computational fluid dynamics (CFD) programme," points out Rosenthal "That's a real differentiator for Forte handling that number of species in roughly the same time frame as other tools handle fifty or so. It's really the ability to understand which sub-component of the fuel is affecting which phenomena and what is going on [in the combustion chamber]."

Pressure points

Engine knock is all about having ignition where it wasn't predicted and where it isn't needed, says Rosenthal, and "that turns out to be a combination of pressure and spontaneous combustion, due to pressure and the fuel-air mixture auto-igniting in a position where it's not helping the engine.

"All the traditional CFD approaches from other businesses relied on chemistry solver technology that was either quite antiquated or required them to really use simplified chemistry



models to be able to get a turn-around time from the simulation. One of the key enablers for us was that we brought in Chemkin-Pro technology, which is a very advanced numerical solver programme, and some really good fuel models to the party."

For Rosenthal, traditional knock control is "a little bit of a guessing game", as sensors tend to react to the phenomena, rather than predicting and then preventing the knock. "There's always a trade-off as you set up the knock control to prevent it. But, if you don't have a good handle on where that is or why it's happening, then you could be setting an excessive or too narrow a margin."

There was, recalls Rosenthal, a major hurdle to overcome, as he explains: "There's an

area here that is non-intuitive, from a physics standpoint, called the 'negative temperature coefficient region' that occurs. As temperature increases, ignition time decreases, except there's an area where it blends out, even though it inserts a longer delay. If you're not accurately predicting this zone of pressure, then you're unable to understand why that secondary flame front happens. This was one of the pieces that made it hard to do this until now – not only understanding what was going on, but really the modelling behind it."

Once that had been understood, Reaction Design then developed a series of virtual pressure sensors, eight in all, while using digital signal processing techniques as a high path

Volvo raises the pressure on diesels

Volvo's next-generation diesel engines will mark a significant step forward in fuel economy, performance and emissions, thanks to the adoption of combustion pressure sensors and the highest injection pressures so far seen on a production passenger vehicle.

Applied to Volvo's new-generation VEA engine family, due to be revealed this autumn, the so-called i-ART diesel technology raises the injection pressure to 2,500 bar and adds a cylinder-by-cylinder pressure sensing system that allows extremely precise monitoring of each of the multiple injection pulses on every

piston stroke. "It's the second step in the diesel revolution," said Derek Crabb, VP of powertrain engineering at Volvo. "It is a breakthrough comparable to when we invented the lambda sensor and the catalytic converter in 1976."

Extra dimension

Speaking to Automotive Design, Crabb explained that the new developments gave engineers an extra dimension of control over the engine's combustion processes. "The more you can get control over the key parameter, which on diesels is the injection,

the more it helps you get a better balance between fuel economy, emissions and performance. It gives you a lot more freedom and a much better chance of getting through future emissions standards."

The Denso common rail injector system runs at an unprecedented 2,500 bar, which allows fuel to be injected faster, more precisely and with a better spray pattern. This, in turn, gives more complete combustion, reducing the loading on the after-treatment system and possibly allowing a simpler system to be fitted.

filter to simulate the flame front in the cylinder head. Typically, the Reaction Design team saw knock occurring on the far side of the cylinder wall, with a variation of as little as 0.3 bar pressure doubling the amount of knock.

"The methodology we're using is really matched to the methodology that a test engineer would use on an actual engine. In other words, he's going to put pressure transducers on the engine and listen for the knock. And we said: 'Well, we're modelling that engine, so we ought to be able to put down these virtual pressures transducers, look at the pressure and listen.'

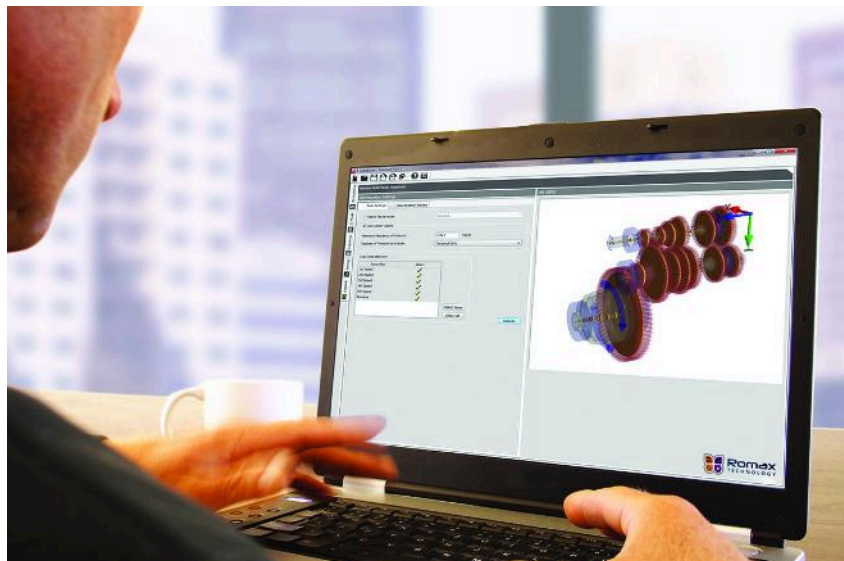
"We stepped back and said, if we were mechanical engineers working on it, how would we be doing this and how are they doing this now? And how close can we get to that, as they will understand it better.

"The other piece is really making these models have the capability to follow what is physically happening. It's not so much a knock model, it's more of a methodology for understanding what's coming out of the simulation, from a combustion standpoint, and translating that into an index that a mechanical engineers could find useful," Rosenthal added.

Strong interest

He foresees engineers using the software to give them a better starting point when developing engine controllers. "The knock sensor engine controller's software programme runs on a real-time basis and I think this understanding will help them get back some of the margin they might be putting in; and certainly avoid not having enough margin."

He reveals that a couple of German and Japanese suppliers have shown "very strong" interest in the system and at least one of the USA's big three.



New software speeds up driveline design

Design processes that normally take weeks can be completed in a matter of hours, thanks to new digital tools from Nottingham-based Romax. The new suite, formed of three components, seamlessly integrates the traditional stages of driveline design and prototyping, allowing analysis and key design decisions to take place in the concept design phase when the design space is wide open. It also allows a lot of options to be investigated, reducing re-work later in the process.

"Ten years ago, people were still building prototypes and testing them to see what broke," said Charles Watson, head of marketing for Romax. "Early CAD systems gave high incremental effectiveness, but now our newer processes don't support legacy processes, but replace them entirely."

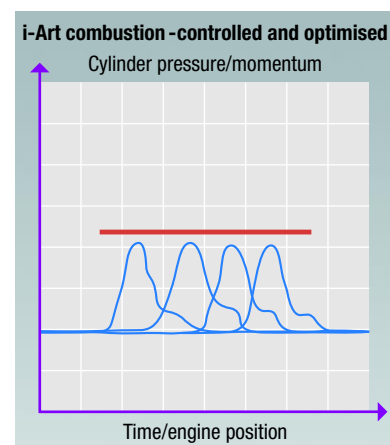
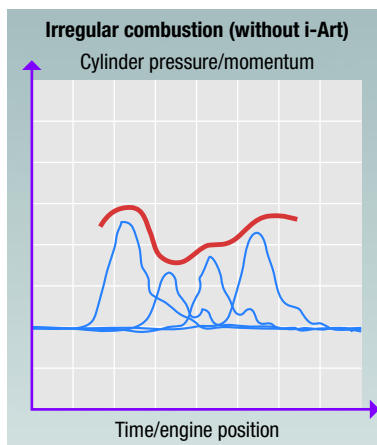
One of the key advances with the new suite, according to Dr Jamie Pears, head of product management, is that it is able to perform detailed analyses and simulations within the design package. Most notably, the system integrates and automates notoriously complicated multi-body dynamics (MBD) techniques, such as Adams, so they can be used in driveline design.

"These MBD models usually take weeks to build," said Pears. "You needed different MBDs for different types and it requires high-end knowledge – that is why MBD is rarely used in driveline design. Our model takes seconds."

Romax's CAD Fusion, Dynamic Fusion and Concept tools will reduce design and development costs, increase innovation and improve driveline efficiency.

The new control system, steered by small computers in each injector, as well as by the central ECU, is also helpful in reducing NVH by adjusting pilot injection through a feedback loop; additionally, the system ensures perfect balance between cylinders, helping emissions, as well as overall smoothness.

Crabb is reluctant to give away too many performance details ahead of i-ART's official launch in September, but confirmed that the system is worth "several per cent, in terms of fuel economy". Direct comparisons would be misleading, he said, as i-ART is part of a downsizing and down-speeding programme that also delivers its own efficiency benefits.





Battle for sustainability honours

BMW claims its forthcoming i3 four-door hatchback will also be the world's most sustainable car – built at the world's most sustainable, wind-turbine powered, carbon-neutral car plant near Leipzig, Germany; although Renault-Dacia might dispute that claim (see Automotive Design January-February 2013).

The i3 has an extruded and cast aluminium chassis, which carries the suspension, steering and driveline, but the passenger cell is made of resin-transfer-moulded (RTM) carbon fibre, with plastic polycarbonate body panels hung on the outside. The carbon fibre is the key to the i3's low

1,250kg weight. BMW has applied systems analysis to mass produce the i3's panels, traditionally produced in an artisanal process.

Low weight the key

"The key to reaching our range and performance targets, as well as having a vehicle that is fun to drive, is to get low weight, because we had to compensate for the battery," says Carsten Breitfeld, head of the i project. "It was a question of how to optimise carbon fibre production. This is territory where no car manufacturer has ever been before; we are redefining automobile construction."

Actually, i3 production is more of a refinement than a redefinition, with BMW streamlining every production stage to remove small amounts of time, expense and waste. It 'bought into' the sourcing process, with a joint venture with carbon specialists SGL Automotive Carbon Fibres to weave carbon thread into flat, dry mats at its hydro-electric-powered plant at Moses Lake, Washington State, USA.

The mats contain a binder agent and, when they arrive in Leipzig, are pre-formed, using ultrasound to set the binder agent and retain the shape. Each body side uses nine separate preformed panels, with the excess trimmed, recombined and used to make the i3's roof. The preformed mats are hand placed in the mould, which is held partly open while injected with resin at 80bar, then closed and heated to 100°C to speed setting. The panels are then trimmed, cleaned and the required holes cut, using water jets. The body is assembled by robots to ensure accuracy, using 160 metres of Dow Corning two-pack polyurethane adhesive.

Key body assembly processes are carried out by 160 robots in the assembly hall to reduce the risk of contamination. It's slower than



Renault-Nissan EVs.

ZF has developed a plastic engine mount that is 25% lighter than comparable rubber-metal designs and 100% recyclable.

Manufactured from fibre-glass reinforced polyamide, its modular construction allows it to be used with various engines in different cars. It is already being produced in six model-specific versions for small and compact cars, as well as

Four-way cat for petrol engines

BASF has introduced an innovative four-way conversion catalyst (FWC) for petrol engines. The single-component FWC technology can remove PM (particulate matter), as well as CO (carbon monoxide), HC (hydrocarbons) and NOx (nitrogen oxides) from gasoline-engine exhaust, helping OEMs meet strict new emissions regulations, including Euro 6.

The traditional three-way catalyst (TWC) used with gasoline engines removes CO, HC and NOx. In order to remove PM, a separate gasoline particulate filter can be added. However, this can increase back pressure and requires additional space. The FWC addresses this challenge, creating a single-component technology solution, states BASF.

"Close collaboration between catalyst developers, substrate suppliers and OEMs will be required to bring the full potential of the FWC to market," said Xavier Susterac, BASF's vice president, Mobile Emissions Catalysts Europe. "BASF will continue to drive this process, leveraging our industry-leading innovation capabilities, and our proven emissions control and catalysis manufacturing expertise, to help move the industry forward."

No more whining

The latest generation of downsized, 2-, 3- and 4-cylinder engines, with 5-speed transmission and 6-speed 'boxes on the increase, present their own unique set of noise, vibration and harshness (NVH) issues, claims TrelleborgVibracoustic, often demanding the use of a secondary damper at extra cost and weight.

TrelleborgVibracoustic has combined its expertise in both powertrain mounting solutions and mass damper technologies to produce a gear-box mount with an integrated mass absorber, eliminating the need for the secondary damper, and creating significant weight and cost savings. What's more, the mount can be readily tuned to tailor it to specific frequencies, making it suitable for multiple applications, says the company.

"The essential feature of the product is the rubber lobes that sit on either side of the main spring. Using advanced design tools, we are able to tune the thickness and height of these lobes to target multiple frequencies" says Enrico Kruse, director of product innovation. "Gearbox whine is a growing phenomenon, and our customers are increasingly asking for innovative, cost-efficient solutions.

This new mounting design can be tuned to combat specific frequencies and, at the same time, eliminates the need for additional components."



classic stamped-steel car plant, but eliminating the press shop and the paint shop saves time, as does using ultrasound and infra-red to speed glue-setting times.

Production line investment is lower, too, with fewer conveyors, no welding and, apart from the glueing robots, the handling machines are lighter-duty models, as they don't have to carry the same weight as steel panels. The body shop is also quieter and cleaner than a traditional metal-bashing plant, although some of the environmental claims for the i3 facility depend on another plant spray painting the body panels.

BMW claims that in the 100 or so crash tests it has performed on the i3, its carbon-fibre construction is at least as safe, if not safer, in a crash – particularly the side-impact pylon test, where honeycomb sill sections absorb impact more successfully than metal. In the event of an impact, the main battery is isolated, using an explosive fuse, while the residual system charge is drained and the motor regeneration electronics are isolated.

The i3's 230kg, 22kWh square battery pack sits under the floor, cooled by passing wind and the car's air-conditioning, is protected by the chassis and carbon fibre body. It uses 96 Samsung cells, but the installation, the aluminium-alloy case, and the control electronics and software are BMW design.



New move to ensure safe software development processes

To help OEMs comply with key industry safety-related systems, PTC has released the latest version of its application lifecycle management solution PTC Integrity, which has been certified as fit for purpose for functional safety development, in alignment with IEC 61508 and ISO 26262.

The software manages all global software development processes and connects all software engineering artefacts, including requirements, models, code and testing, to ensure comprehensive lifecycle traceability. Its open architecture allows it to integrate disparate tools into a streamlined software system engineering process to enable the orchestration of software change and collaboration across the technology supply chain.

The PTC Integrity development organisation has also achieved Capability Level 2 under the Automotive SPICE (Software Process Improvement and Capability Determination) framework. "Automotive development organisations are managing complex requirements for embedded software in their products," explains Jake Simpson, divisional general manager, ALM segment, PTC. "Continuing to certify PTC Integrity with automotive safety industry standards like A-SPICE and ISO 26262 will help our customers comply with functional safety standards to ensure safe software development processes."

TÜV SÜD Automotive has certified that PTC Integrity is fit for purpose to develop safety-related systems for use in ISO 26262 and IEC 61508-compliant development processes.

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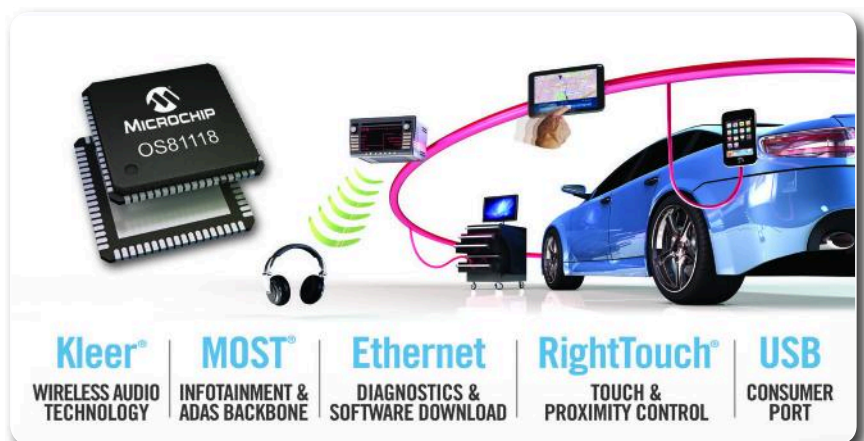
MOST technology is the de-facto standard in the automotive industry for infotainment and Advanced Driver Assistance System (ADAS) networks. Now, Microchip's new OS81118 simplifies in-car mobile and WiFi® connectivity over MOST150.

Already used as the backbone for in-car infotainment in more than 140 car models worldwide, MOST's synchronous network technology delivers cost- and bandwidth-efficiency for transmitting audio, video, data and control information between any attached devices. Its ultra-low latency, high quality of service and minimum hardware is available across three speed grades of 25, 50 and 150 Mb/s, with support for optical and electrical physical layer.

With 150 Mb/s bandwidth and an automotive-grade physical layer for Ethernet protocols the highest speed grade, MOST150, now introduces support for in-car internet, email, social networking and connection to the cloud.

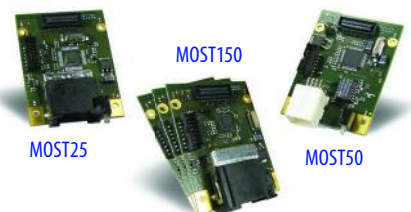
To simplify the development of this new level of in-car infotainment, Microchip has released the latest member of its MOST150 INIC family: The OS81118 features on-chip USB 2.0 high-speed device port for easy USB connection to standard Wi-Fi/3G/LTE modules and to multi-core consumer Systems-on-a-Chip. Additionally the integrated coax transceiver offers a low cost electrical physical layer.

For more information visit:
www.microchip.com/get/euOS81118



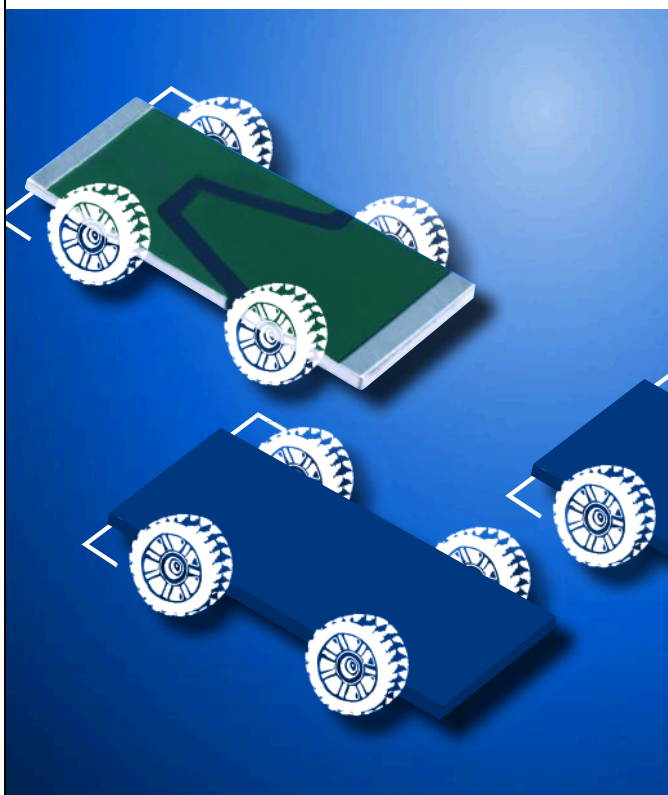
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News in brief

Bentley W12 upgrade

Bentley is developing cylinder deactivation for its six-litre W12 engine, according to sources in the company. It is expected to be announced within 12-18 months, Automotive Design was told. The engine will employ the same technology as that which Bentley developed with Audi for its V8 and could result in significant fuel savings – in double figure percentage points. The biggest challenge is synchronising the W16 cylinders to run as an eight-cylinder unit.

Split the difference

ContiTech AG has reorganised its heating/cooling/turbocharger division into separate, more effective divisions: the heating and cooling systems will concentrate on water-related areas, while the newly formed air induction systems segment will be dedicated to all air induction product lines.

Harman acquisition

Harman has bought iOnRoad Technologies, Ltd. Based in Tel Aviv, Israel, iOnRoad is a recognised leader in the development of advanced driver assistance systems (ADAS), including the iOnRoad augmented reality driving app. iOnRoad technology does not require dedicated hardware and runs on a variety of software platforms, including Android, iOS, Windows and Linux. The iOnRoad app offers a suite of driving assistance functions, including augmented driving, collision warning and lane departure warning.

Denso European expansion

Denso has invested €3.9 million in a new instrument cluster factory in Myslowice, Poland, to strengthen its European footprint. Production is due to start in August this year.

CSP land in France

Continental Structural Plastics (CSP) has signed a framework agreement to lease manufacturing floor space in Pouance, France. The agreement also includes the purchase of assets from a composites manufacturer that was formerly located in the facility CSP will lease.

"The Pouance acquisition improves CSP's ability to provide our customers with exceptional global support, in terms of manufacturing and service," said Frank Macher, chairman and CEO of CSP. "The agreement expands our global network, increases CSP's manufacturing capacity and provides us with the opportunity to expand our customer base in Europe."

The agreement includes 11,148m² of floor space, three compression moulding presses, 12 thermoplastic injection presses and one thermoset injection unit, as well as supporting equipment. Staffing of the facility has started and production is expected to begin later this year.

Got it taped

A new portfolio of cost-effective, high-end elastomeric adhesive tapes, developed to adhere to curved surfaces and a variety of low surface energy (LSE) substrates in automotive construction applications, is now available from Avery Dennison Performance Tapes.

Innovation shows the way



The 17th-century German writer and artist Goethe had a quote that, to me, perfectly captures the essence of innovation. He wrote: "Daring ideas are like chessmen moved forward; they may be beaten, but they may start a winning game."

That especially rings true for mobility engineering. And, it seems that more times than not, the forward progress of innovation leads to winning moves.

But that innovation needs to continue; we need to create environments that nurture innovative thinking and enable today's professionals to take risks that lead to better ideas.

Recently, I read an article in The Economist that talked about how the accumulation of knowledge and data is increasing, but innovation may be flattening out. If that indeed is the case, then changes must be made.

Think about how the mobility engineering industry has evolved over the years; think about the advancements that have been achieved in safety and efficiency, all because of innovative thinking.

Examples can be found everywhere, especially in the work that SAE International and its members have done over the years. SAE's technical standards, both for aerospace and ground vehicle, are

considered to be premier documents around the world. The technical guidelines they provide help organisations and companies make better, safer products, many times in a more efficient way.

But SAE's technical standards aren't effective and ground-breaking because they relate to technology that already has been developed. Rather, the engineering professionals who help develop them have a keen sense for what kinds of technology are on the horizon and the standards are created to meet that technology.

An excellent example of that lies in the SAE standards created for charging of hybrid and electric vehicles. Development of the standards began before the technology really started to hit the showrooms for consumers' use. And the new fast-charging coupler standard introduced by SAE International reaches into the next level of technology.

But innovation doesn't just end with the parts that comprise vehicles or the vehicles themselves, true innovation affects society as a whole.

When purchasing a new vehicle, consumers expect more than just a way to go from one point to another; they expect a full experience that includes safety, reliability, and entertainment. They

want to incorporate their smartphones into the vehicle itself and be able to access everything they could at home or in the office. Innovation made that possible.

Travellers who step onto a jetliner want the latest in infotainment technology, allowing them to enjoy the flight or get crucial business done as they travel to their intended destination. Innovation made that possible.

The truly wonderful thing about innovation is that there is no end game to it. There is no summit that can be scaled and the journey declared over. Rather, it's ongoing...as long as we choose to make it ongoing.

And that's the challenge we have; let's keep the chess pieces of innovation moving forward in the boardrooms, in the design labs, on the productions floors and within SAE International.

If we do, the future of mobility engineering will shine as bright as its past.

focus@sae.org

Valve controls – infinite possibilities

Imagine a valve control system that is infinitely variable irrespective of engine speed and load. Impossible? Not according to Camcon Automotive's technical director Roger Stone, as Ian Adcock discovers

A valve control system that operates in real time, adjusting individual valves according to the demands of each cylinder and power stroke, seems like a dream come true for engine designers.

It's a step-change in engine design and development that is probably even more important in the long run than the switch from points ignition to engine management systems or the move from carburettors to fuel injection.

Such a significant move forward, says Roger Stone, Camcon Automotive's technical director, unlocks an Aladdin's cave of possibilities. As he puts it, in terms reminiscent of former US Defence

Secretary Donald Rumsfeld's 'there are also unknown unknowns': "One of the things I keep saying about intelligent valve actuation (IVA) is 'There are things we will be able to do with it, that we don't know we want to do yet'."

Unlocking the obstacles

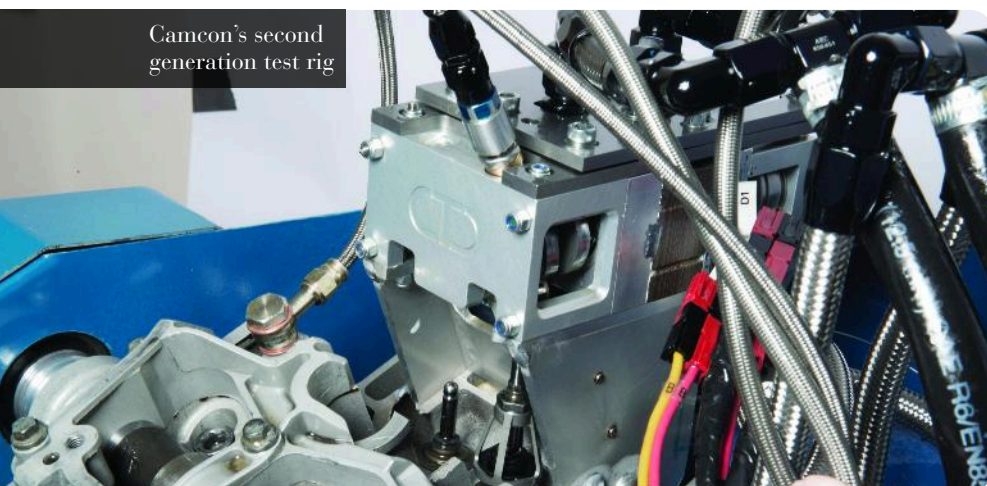
Equally applicable to petrol and diesel, IVA, Stone believes, could, amongst other things, unlock the difficulties that homogenous charge compression ignition (HCCI) is currently presenting to manufacturers, such as Mercedes-Benz, trying to develop it. "Potentially it's an enabler for HCCI. For example, at lower speeds we are fast enough to get more than one valve cycle in during a 720° period, so we could have the normal exhaust event, if you like,

followed by an additional smaller event during the inlet stroke to give us the amount of exhaust radicals that we need."


Meanwhile, he is equally convinced that, because the link between the valves and the crank is broken, it would be possible to open the valves every stroke between 2,000 and 3,000rpm to run the engine as a two-stroke for short periods of time. "Even the ability to run for short periods as a two-stroke is thrown in for free, although you get the breathing compromises that are inherent in a two-stroke."

He talks enthusiastically about the ability to run Miller Cycle where the intake valve is left open longer than it would be in an Otto cycle engine and of sophisticated cylinder deactivation on demand, which he dubs 'roaming' cylinder deactivation. "It varies with the engine configuration, but you can avoid individual cylinders cooling down and giving you a hydrocarbon spike when you restart by running all cylinders, but skipping cycles as necessary, depending on power and torque demands."

Imagine, also, the potential of linking the valve control unit (VCU) into topographical navigation system, so the power and torque demands to maintain a given vehicle speed can be predicted and precisely tailored for the local terrain and traffic conditions, to



Camcon's second generation test rig

A close-up portrait of a middle-aged man with a grey beard and mustache, wearing a light blue shirt. He has his hands clasped in front of him, resting his chin on them. A gold ring is visible on his left ring finger. The background is a solid grey color.

“There are things we will be able to do with it, that we don’t know we want to do yet.”

Roger Stone

CV

Rover Stone (61 years), Camcon Automotive technical director, holds an honorary Doctor Technology from the University of Brighton and has an MSc in automotive technology from Cranfield Institute of Technology. He holds eight patents in the engine technology domain.

Previous roles include: projects manager, Lotus Cars; chief engineer, Rover Cars; technical director, design Ricardo; VP engine systems technology/technical director, AOE Europe VP advanced product development, power transmission Gates Corp; and engineering director, Torotrak. He is married, with 2 children

the extent that cylinders would be deactivated on a real time basis.

Eliminating loss

But one of the obvious and immediate fuel saving benefits – 3.5-6%, according to Stone – would be the elimination of the throttle and its associated pumping losses. “The other great thing is that, whatever the engine load/speed condition is, you don’t have some timing and lift compromise; you have the valve timing, period and lift for that particular event. Our research suggests this will result in an overall FE improvement of more than 15% – both on the statutory cycle and in a real world driving environment.

“In the 70s, before cam phasers started to become more common, the valve timing you had at idle was the same as at maximum revs, whereas at idle you want almost no overlap and at full engine speed you might want

50, 60, 70 degrees overlap. We can do that and, of course, at idle, if only 0.2mm of inlet lift is needed, we can also deliver that.”

The key enabler to Camcon’s IVA is a development of its proprietary Binary Actuation Technology (BAT) invented in the late 90s by Wladyslaw Wygnanski, as Stone explains: “Although the IVA employs a desmodromic valve system, that in itself wasn’t the starting point, although the fact that it doesn’t employ a spring, but a cam and leverage system, lends itself to our application by minimising the actuator size and power demand.

“The Camcon bi-stable actuator is a very low energy and fast actuator. Unlike a solenoid, it has two zero power stable states, whereas a conventional solenoid has only one, requiring either continuous power or an extra mechanism to latch it. With

the Camcon binary system, it’s fired from one end to the other, with no latching, and powered only during the switching operation.”

This feature, says Stone, makes it equally applicable to park brake systems, thereby eliminating a potential noise path into the cabin via any cabling. He adds: “The inspirational leap was, ‘Could we make this multi-stable by rolling it into a multi-pole, rather than two-pole device with a rotating permanent magnet arrangement, to drive a poppet valve with it?’”

Significant funding

“Since 2005, there has been a great deal of Camcon-funded work on the concept and it has been transformed from those early ideas into a sophisticated device, which delivers a real capability greater than any system on the market or, as far as we know, in development.”

Unlike some camless systems seen in the past,

which relied on opposed solenoids to both open and close valves, and on 48volts, Camcon’s runs on a standard 12volt system assisted by an energy recovery system, as Stone explains:

“When the energy recovery cam is at full lift, the energy recovery spring has got maximum strain energy, but generates no torque, as long as the cam is on peak lift. The moment the cam is knocked off peak lift, it acts as a lever, converting the spring force into torque, and starts pushing energy into the mechanism. That gives an energy boost, so less electrical power is required. When the valve closes, so the actuator stops each time; not half engine speed or anything like that – its ‘go’, ‘stop’. So every engine cycle/valve cycle, the actuator stops. And, in stopping, kinetic energy is recovered in the spring and recycled next time round.”

Effectively there are three cams: a

pair of desmodromic driven ones to open and close the valves and a third on the same shaft to operate the energy recovery spring.

Cost, as ever, is an issue and, as in so many instances, is dependent on numbers being manufactured. However, Stone suggests that the IVA will come in at “around the equivalent of a diesel injection system of one thousand pounds or euros, or thereabouts”, of which the VCU represents “a big chunk”.

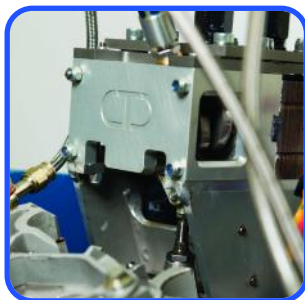
Mix ‘n’ match

What this means to the OEM, says Stone, is that they can mix ‘n’ match the valve train, according to an engine’s individual requirements: “You could have one actuator per valve or just do the inlets only and have conventional exhausts; or you could tandem them up, so there’s one IVA actuator between a pair of valves. Or, go the whole hog on the inlets, with individual actuators and tandem them on the exhausts. If you have independent control on every valve, you have more flexibility and benefits than if you compromise.

“The £1,000 would be at the top end of the range; if you only spend half that, you don’t quite get half the system, as the VCU will be a significant investment.”

Further savings can be made, depending on the engine’s architecture, claims Stone. “It’s a new head, obviously. In terms of the bottom end, it’s delete really, as we don’t need the timing drive any more, unless you run the exhaust cam; in which case, it’s even simpler: you just delete the inlet sprocket. It depends on the individual design of the engine. If the water pump is driven by the timing chain, it’s a bit more complicated than just deleting the timing drive, but IVA could be retro fitted or run as a derivative, with other more conventional variations of the same engine family alongside each other.”

The beauty of the system is that OEMs can tune it to meet their own



specific requirements of bmep, emissions and fuel consumption, as well as helping to minimise knock by improved control of residuals and the effective compression ratio. To achieve this, says Stone, the VCU has to be significantly faster than any other controller currently in use on an engine. "It's extremely important to get the controlling algorithms right. The power consumption depends on the quality of that algorithm and that's an area we're particularly active in at the moment. By automotive standards, it needs to be significantly faster than an ignition or fuelling ECU, because we've got to be looking at where the valve is multiple times per event – over 100 times per event –, whereas an ignition ECU only has to do its sums per cylinder once every other revolution. We've got a lot of computing to do; we're talking about probably 10 times faster – a 100 microsecond computing cycle."

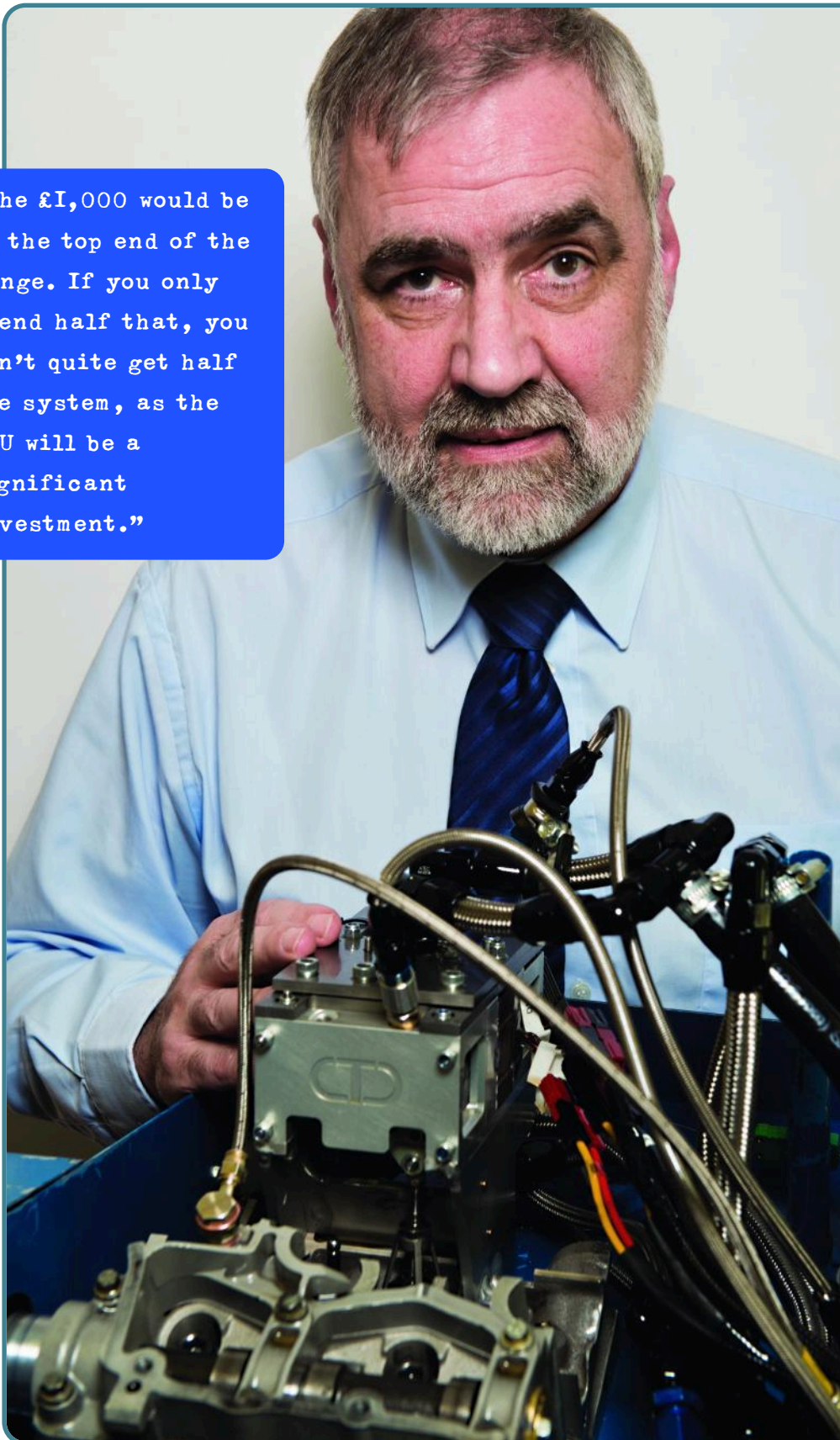
Fast forward

Asked if there are no downsides to this technology, Stone smiles and laughs briefly. "It's going to be embarrassing for the injector suppliers, because the great thing about having only tiny lift is that there's a very small amount of energy used - it's practically silent at idle and, even at full engine speed, it's noticeably quieter than standard valve trains."

Now working towards its third generation of development rig, Camcon is seriously courting interest from the industry. "We do have interest from OEMs, but ultimately we're looking for a tier one to take on the industrialisation. We need a very serious level of interest from an engine producer, in order to encourage a tier one that there will be a market for it."

"It would be nice to think that we could move it forward quickly enough to be in service, with some reasonable experience, before the 2020 regulations come in; maybe 2018. It all depends on what happens from here."

"The £1,000 would be at the top end of the range. If you only spend half that, you don't quite get half the system, as the VCU will be a significant investment."





Mother Nature

More than any other trend or technology, light weighting – building cars from increasingly lightweight materials – holds the key to increased fuel and energy efficiency, and reduced CO₂ emissions.

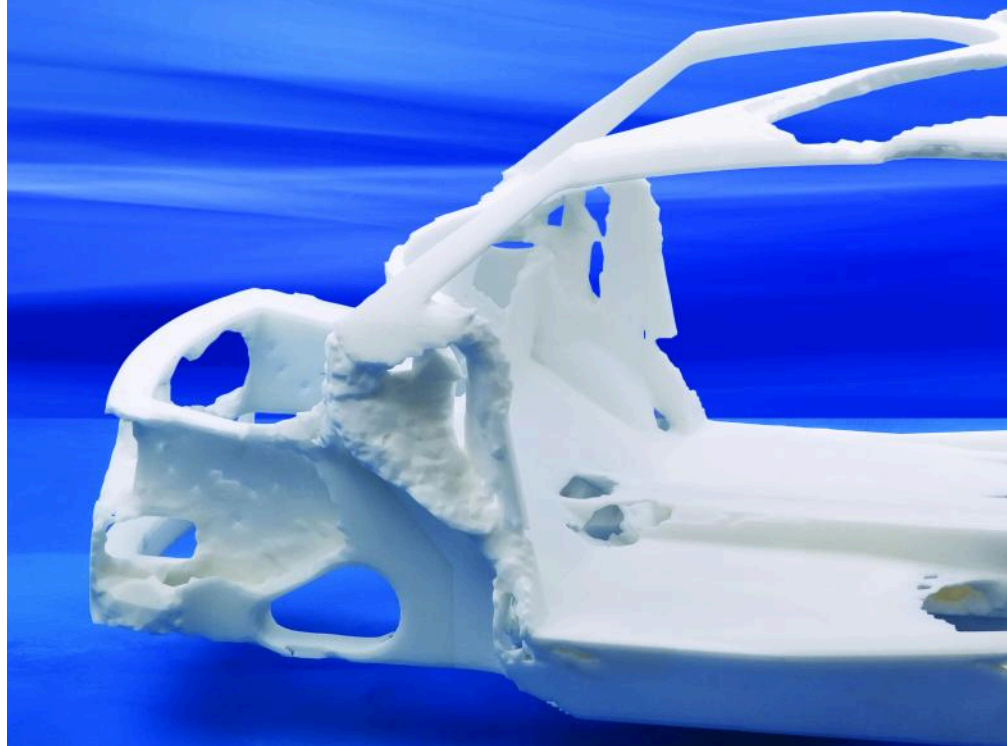
The body-in-white is the area in which this could have the most impact. Replacing traditional steel bodies with aluminium, lighter weight steels, including advanced high strength steel (AHSS) and magnesium – or by using alternative materials, including carbon composites or plastics, either entirely or proportionally – will help alleviate some of the pressure that the automotive industry is under to reduce fuel consumption and emissions.

Fundamental changes

So far, most progress in the area of alternative materials has been made at component level, although there are moves to replace the car body's sheet metal components with alternatives, including BMW's use of carbon fibre reduced plastics (CFRP) for its forthcoming i3 and i8 models, and the use of carbon fibre for hypercars, including the Ferrari LaFerrari and McLaren P1.

But what if the fundamental structural design of cars needs to change? The trend to reassess the manner in which vehicles are constructed is gaining momentum. One area that is attracting an increasing amount of interest is in the biomimicry or biologically inspired design.

Unless you're a naive creationist, you'll appreciate the massive contribution 3.8 billion years of evolution has made to the design of



What can the automotive industry learn from nature when it comes to weight saving?
Ryan Borroff has been finding out

the natural world. At the very least, Mother Nature's design solutions to nature's engineering problems could represent a huge saving to a manufacturer's R&D budget, if OEMs take inspiration from, or mimic elements in, the natural world and apply them to their own engineering design.

Today, the science of biomimicry is evolving, due to advances in materials and manufacturing developments – particularly in the fields of carbon composites and 3D printing. The aerospace industry has been one of the first to look to the natural world for inspiration in the construction of aircraft. Aerospace has long been



Mercedes-Benz Bionic Car used Computer Aided Optimisation and Soft Kill Option software

knows best



about the creation of efficient aerodynamic designs that are rigid and lightweight, with the aim of minimising drag, and maximising flight range and fuel efficiency.

Topology optimisation

Airbus has been using OptiStruct software by Altair Engineering to optimise the A350's design to reduce weight and cost, while improving performance. The OptiStruct software uses a process known as 'topology optimisation' to evolve the optimal lightweight shape for a structural design. Topology optimisation uses a finite element analysis (FEA) algorithm to evolve the ideal lightweight shape for a structural design. The process involves the removal of any mass that performs no function and adds mass to enable consistent stress distribution, eliminating stress points and creating key load paths.

Notice the word 'evolve'. This is a process similar to what nature has done to optimise the evolutionary development of bones – bird wings are the most commonly cited example in the aerospace industry, for obvious reasons – though it applies to other natural elements, including trees and other plant life. You don't have to be a Darwinist to appreciate that this is a similar method to natural evolution.



The concept car achieved a 0.19 cd value



Dr Robert Yancey –
“We can take a lot of
clues from nature”

“The biomimicry trend has real potential,” explains Dr Robert Yancey, senior director, global aerospace, energy, and marine, Altair, USA. “In aerospace, most composite structures are made using continuous fibre composites, which are continuous long strands of carbon fibre embedded in a resin matrix. When you look to nature, there are a lot of composites – bone, wood, a lot of plants and so forth. In most cases, they are not continuous fibre natural composites; they are shorter fibres; with fibres that line up with the major load direction. That is a more efficient way of designing a structure. We have a lot of work to do on figuring out how we can manufacture objects like that; but we can take a lot of clues from nature regarding composite design.

“We’ve carried out a lot of structural optimisation work in the aerospace industry and the type of structures that our software produces is more organic in nature, in terms of shape. Bird bones have an interior structure that also reduces weight. If we can learn from nature, and be able to start incorporating [these] types of design in our automobiles and aeroplanes, then we will further reduce weight.”

Naturally inspired

But will a similar approach work in the automotive industry? Professor Dale Harrow, dean of school and head of programme, vehicle design, Royal College of Art, believes that it will, helped by the way in which car design thinking is changing. “Car designers have been inspired by nature for years,” he explains. “But, until recently, they’ve only really been looking at it from a surface perspective. The difference now is that we can design in three dimensions more than ever before. You can build up very complex structures and think about structures in a very different way from the way that you used to.

“The trends here at the RCA are using multi-layers, tapering structures, bird bone images and so on, all inspiring new sorts of structures. It’s very different to the old engineering structures of putting bits of tube together or pressing things. The rapid manufacturing processes enable you to produce scale designs, but there is no reason why this couldn’t be scaled up. A student here has designed a car that can be 3D-printed and, because you can blend materials together, it gives you massive amounts of freedom, in terms of boundary layers, and you can also vary the strength enormously. For example, in the chassis you can build-in enormous



Bionic car inspired by the boxfish

amounts of strength, because you can easily build in triangulated sections; something you could never do normally.”

The ascent of computer aided design over the last 20 years has resulted in designers increasingly thinking in a much more three-dimensional manner – in a way their predecessors did not. The design process allows for visualisation in this way, but, according to Harrow, “it also allows the imagination of shapes that you could never hand-model or draw; shapes within shapes, too, even if you look at the potential for 3D printing.”

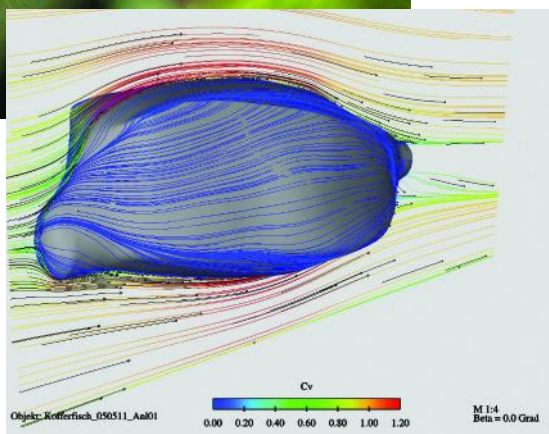
More organic design

So far, work in this area – the



Aerobus is researching biomimicry for future aircraft interiors

Biomimicry



manufacturing of three-dimensional components that have been biologically inspired – has been done at a cottage scale, on projects such as the development of the Bloodhound SSC (SuperSonic Car). Cambridge Design Partnership is developing the steering wheel design for world land speed record holder Andy Green for the Bloodhound SSC,



using a design based on biomimicry. CDP is taking these initial concepts and optimising them for driver ergonomics. The steering wheel is 3D printed and so can be tailored specifically for Andy Green's needs.

"It allows us the ability to lay down the minimum amount of material required to carry the stresses. It allows a more organic design," explains Dr Jez Clements, partner, Cambridge Design

Partnership. "3D printing is a great way to make a part based on biomimicry, because bones actually lay down material and absorb material, dependent on the stress experienced in a given area, minimising the energy and material required." For now, the material is 3D printed in ABS – the same material as that used in Lego bricks – but the final piece will be 3D printed in titanium.

Moving forward, it's clear that, for biomimicry to be the engineering game changer some people are predicting, structural components – whether designed using topology optimisation or not – will need to be both 3D printed and very strong; which is one reason why the continuing development of a graphene-based 3D printing material is anticipated with such excitement. Whether the automotive industry can afford to produce such complex biologically-inspired components remains to be seen. The big question, says Harrow, is whether these processes can scale up in the volumes the industry will need.

Scale and customisation

"The car industry could scale up, because it has the resources to do so. There is also the potential for a lot more customisation, with consumers even able to have an input into the design process. And, if you are able



© Royal College of Art

Dale Harrow

"Car designers have been inspired by nature for years"

to save 30% in weight, because you are able to design fully three-dimensionally, then the implications for sustainability are huge," he points out.

"When you look at the amount of detail that is being put into headlights now, I can't imagine how that would have been possible without the ability to visualise and model in 3D. At the moment, there are boundaries. If you look at the A-pillar, it's thick, because you want to increase the rake of the windscreen. If you could control the A-post, so it's only strong where it needs to be, or also change the interface between glass and hard material, you could have a semi translucent A-post, with more freedom of form and less limitations."

Such design freedom, in tandem with advanced engineering principles with a basis in the natural world, utilising advanced materials, really could be the game-changer the automotive industry is looking for. Perhaps it is not a question of whether the car industry can afford to adopt such processes. Rather, as cars become more and more niche, with more and more customisation offered, the automotive industry can't afford not to.



Building up the pressure

Tony Lewin reports on the growing trend towards even higher line pressures in injection systems.

All too often overlooked amid today's rush to downsize, downspeed and turbocharge is the very process that gives automobile engines their name – the combustion process itself. And central in that process, in modern engines at least, is fuel injection. It is the major influence on how the fuel burns, and thus how much power the engine produces and the composition of its exhaust emissions.

Most of the significant quantum jumps in engine performance over the past century can be traced back to innovations in the way the fuel or combustible mixture is delivered to the combustion chamber. First seen

on the exotic Mercedes 300SL in the 1950s, fuel injection brought the accurate metering of petrol in place of the more or less haphazard fuel admission provided by the carburettor. However, it was not until the 1980s and 1990s, with the widespread adoption of emissions limits and catalysts, that electronically controlled petrol injection became a near-universal fitment.

The next move to direct injection into the cylinder, is well underway in Europe, but is still at an earlier stage in other markets; again, the benefits in terms of efficiency and certain emissions are clear to see, and the synergies with lean burn combustion and turbocharging are powerful

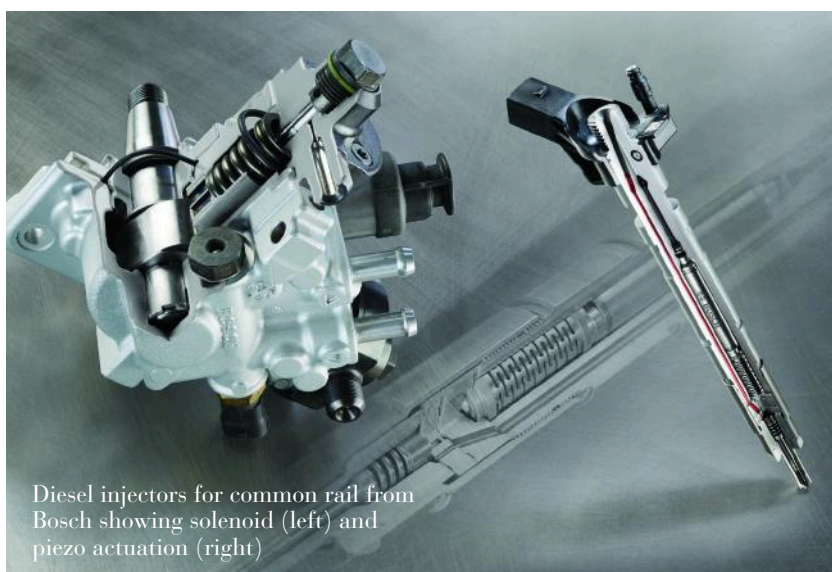
enough to allow useful downsizing of the whole engine, with attendant benefits in parasitic loss reduction.

CRITICAL ROLE

With the rise of petrol/gasoline direct injection (GDI) has come a new science: that of injector nozzle design. Irrespective of the pressures involved, the shaping of the nozzle and its holes plays a critical role in how the air/fuel mixture in the cylinder is distributed, and thus how the engine performs, in terms of start-up emissions, combustion stability and transient response.

On the diesel side, ever since Rudolf Diesel's first prototypes ran around the turn of the 20th century, all diesel engines have required some form of pressurised fuel injection.

Major steps along the way to today's prevalence of direct injection (DI) in the light vehicle segment have been the first passenger car DI from Fiat in the 1980s and the first common rail systems, again from Fiat, in the 1990s. The steady encroachment of electronic control, hand in hand with important developments in injector design – especially the piezo-electric nozzle – have brought dramatic increases in power and efficiency in the past decade, to the extent that diesels can now dominate endurance racing, as well as fly the flag for extreme economy in city cars.



Diesel injectors for common rail from Bosch showing solenoid (left) and piezo actuation (right)

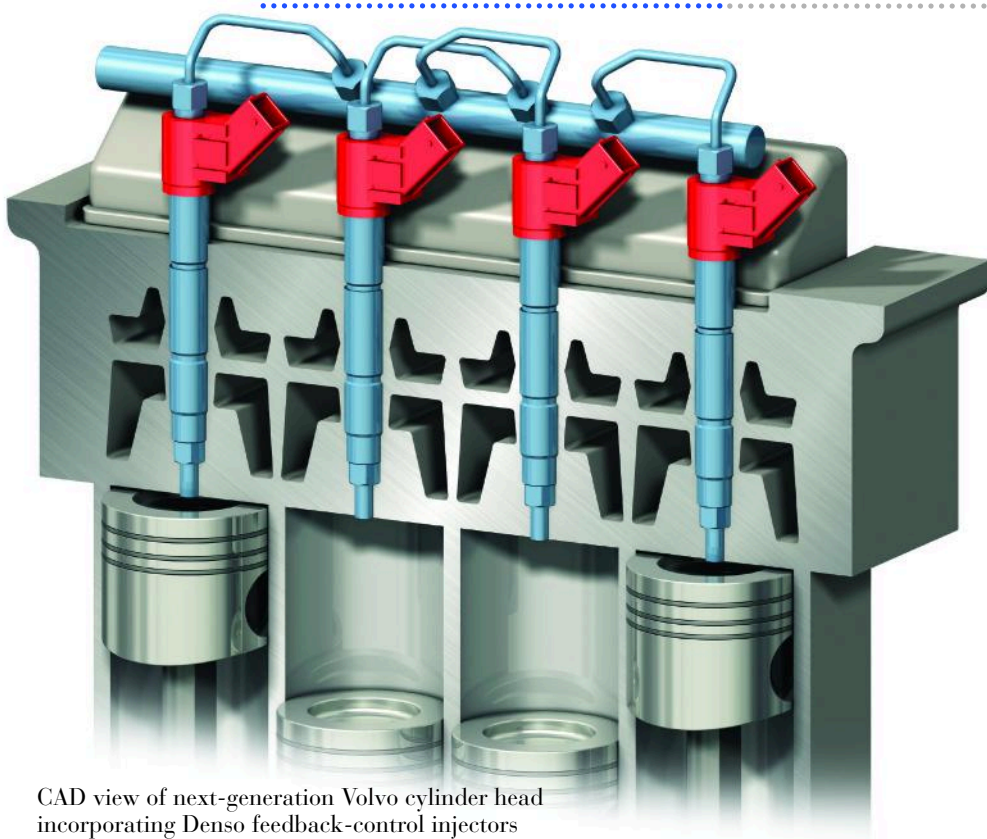
Fuel injection systems

STATE OF THE ART

Perhaps the clearest evidence of how far diesel power has come is provided by two recently announced developments, from Volvo and Volkswagen. Volvo's new i-ART generation of diesels, due later this year, ramps fuel injection pressures up to an unprecedented 2,500 bar (the highest prior to this has been 2,200 bar) and incorporates combustion pressure sensors to enable precise injection rate shaping at all times.

"The system measures the pressure pulse going through the injector," says Derek Crabb, head of powertrain at Volvo and the architect of the new-generation engines. "The higher pressure allows you to inject more fuel, but what you're really after as an engineer is better spray pattern, so you get more effective combustion. The droplets become smaller and break up, giving more complete combustion, without leaving residuals that generate hydrocarbon emissions."

While Crabb is reluctant to give precise details on the performance improvements delivered by the new technology, he says it is "a major help" in achieving the new Euro 6 and possibly future Euro 7 standards, and that the gains are worth "several per cent" when it comes to fuel economy.



CAD view of next-generation Volvo cylinder head incorporating Denso feedback-control injectors

Further major gains could be had in the area of NVH, hints Crabb, where careful control of the pilot phase of the injection pulse can help spread out the combustion event and thus reduce the noise profile of the engine.

Whereas the Volvo engine is expected to major on efficiency and low emissions, the high-performance diesel referred to by VW group CEO Martin Winterkorn is unashamedly

aimed at high power outputs. Though few firm details have so far been given, what Prof Winterkorn did say was that, with 3,000 bar injection, the engine would achieve a specific power of 100kW (134Bhp) per litre; sources within VW point to two-stage supercharging, with an electric turbine feeding into an exhaust-driven turbo.

BMW has already reached a claimed 93 kW per litre with a triple

WHY PRECISION MATTERS

Absolute accuracy and consistency between the injectors on an individual engine can make it not only smoother, but also more powerful, cleaner and longer lasting. Denso's fourth-generation injectors feed back their precise characteristics to the engine management system, so the electronics can automatically compensate for any wear that occurs or for any differences between individual injectors.

"With a conventional engine, you have to calibrate it to, say, 80% of the emissions limits just to allow for variability from engine to engine," says Derek Crabb, head of powertrain at Volvo. "That way, you give away economy, performance and refinement."

With a technology that is able to compensate for variability and in-service drift, he says, engines can be tuned much closer to the 100% box and still stay within the legislative limits over their lifetime. "We can then get back performance, get back fuel economy. That's basically what we're doing with this system."



Injectors will soon be capable of 2,500 - 3,000 bar

Fuel injection systems

turbo engine running at 2,200 bar injection pressure, while Denso, which supplies the complete 2,500 bar common rail system for the new Volvo engines, is promising to reach 3,000 bar in 2015. In a research paper published in 2011, Denso engineers discuss EGR rates of over 40% to achieve NOx emission values 20% lower than today's rates, with increased boost helping reduce smoke emissions, and post-injection events reducing soot output and easing the load on the after-treatment system.

PIEZO-ELECTRIC OR SOLENOID OPERATED?

As well as upsetting big-hitters such as Bosch, the pioneering of piezo-electric injectors by Siemens VDO (now part of Continental AG) in 2000 provided a huge stimulus to the diesel market. Much faster and with greater switching accuracy than the traditional solenoid or unit injectors, piezo injectors allowed engine designers far greater freedom in creating complex multiple injection patterns that improved efficiency, reduced emissions, and made diesels smoother and more civilised.

Continental is now working on piezo-electric injectors capable of handling up to 2,500 bar, operating in conjunction with closed loop control similar to that of Denso. The new injectors have miniaturised piezo stacks, enabling greater hydraulic

efficiency and much reduced leakage; an important factor when vehicles have stop-start enabled.

Denso engineers agree that it is possible to meet upcoming requirements using piezo-electric activation, which, according to Bosch, is 10 times more powerful than solenoid operation. However, in electing to go for solenoid injectors for its G4S fourth-generation common rail system, as fitted to the new Volvo engines, Denso cites the higher robustness and longer lifetimes of solenoids – clearly an important consideration when the self-compensating feedback loop allows the injector to continue working indefinitely at peak performance.

Bosch, too, is working on 2,500 bar solutions using piezo injectors. For precisely metering the tiniest amounts for advance and post-injection, as well as for consistent quality over its service life, the inline piezo injector satisfies the highest standards, says the company, and, thanks to its modular design, this system can be adapted to the requirements of engines with between 4 and 12 cylinders.

GASOLINE DIRECT INJECTION

Fuel pressures in petrol engines are much lower, generally running at between 100 and 200 bar, though Marelli is testing systems at 500 bar. The current attention in GDI is on

particulate matter (PM), something of a surprise discovery on early engines and now thrown into sharper focus by Euro 6 regulations that stipulate particle numbers.

The injector spray pattern must thus avoid wetting the cylinder walls and other components at start-up – a cause of raised PM emissions – yet it must also generate a concentrated zone of air-fuel mixture that can burn stably at part loads, allowing the engine to operate in its economical lean-burn mode for as much of its duty cycle as possible.

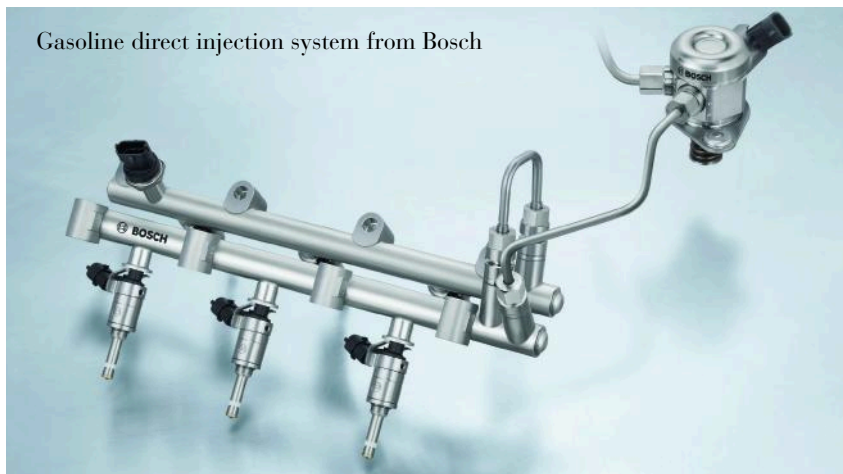
Again, multiple injections, often with fuel quantities as minute as 1 milligramme, are key to stable combustion. Ricardo has demonstrated this in its HyBoost project engine, based on the three-cylinder Ford Fox GDI: injections during the intake and compression strokes allow EGR to be increased, helping cut raw NOx emissions – and giving 160Bhp (119kW) from one litre.

WITHIN REACH

The message coming from the automakers and the top suppliers is clear: with the aid of key technologies such as the latest fuel injection systems, the 95 g CO2 threshold is well within reach for 2020; certainly for city and compact-sized cars, even those with petrol engines. VW's engines are already among the best, but CEO Martin Winterkorn expects further efficiency increases in the group's TDI and TSI engines of 15% by 2020. Bosch, likewise, signals the potential for a 30% gain between 2011 and 2020, and even a seemingly small development such as Denso's new injector is alone worth a 1% improvement.

Small wonder, then, that diesel is set to go on to even greater things – but do not dismiss petrol. Volkswagen insiders say that, however much its engineers improve diesel performance, parallel improvements are in the pipeline for petrol, too.

Gasoline direct injection system from Bosch



Scratch-resistant and Lightweight Surfaces for Vehicle Interiors

Hanover, May 2013. Under the DESIGNED GREEN label, Benecke-Kaliko develops surface materials for automotive interiors that are kind to the environment, help preserve resources and combine quality, comfort and sustainability in perfect harmony. This applies to like soft trim for instrument panels, sun visors, glove compartment doors, air bag covers, door and side paneling, seating, center consoles and convertible hooding. Benecke-Kaliko materials are, however, also used in trucks, busses, aircraft, ships, rail vehicles and recreational vehicles.

The company's latest innovation involves TPO materials with a very special property: They elude sharp objects, making scratches a thing of the past. Benecke-Kaliko addresses the demand for high-quality yet resistant materials with no fewer than three innovative products. In addition to the already familiar DecoJect™ thin foil, this development makes use of the TEPEO® and TEPEO 2® Protect surface materials, which are highly resistant to scratches. It can be used in all areas where scratches could typically ruin the visual effect: On the instrument panel, the center console, the storage compartment, or door and interior trims. No matter whether on holiday or business trips or simply when using the car for everyday driving, car owners and all passengers can thus enjoy the ride without the irritation of unsightly scratches.

The differences among the three scratch-proof materials are to be found in their application and processing. The light foil TEPEO 2® Protect has been designed mainly for high-quality passenger cars. This application enables offering the ultra finely structured soft surface materials customers demand. With all TEPEO 2® materials, the grain has a particularly stable design, because Benecke-Kaliko is the only manufacturer to follow grain-forming embossing up with a process of electron-beam crosslinking.



This renders the polymer structure particularly stable, so that the grain structure is re-tained with maximum depth of detail and homogeneous quality even after the foil has been processed. In addition to their scratch resistance, which is due to specially developed foil formulas, the foils are sealed with a special easy-clean polyurethane varnish. A major advantage for car rental companies as well: The material properties prevent damage caused by frequent cleaning with appropriate cleaning agents.

TEPEO® Protect is also used in the manufacture of high-quality soft surfaces for vehicle interiors. Unlike TEPEO 2® Protect, however, TEPEO® Protect has been optimized for processes where the grain is embossed during component production using IMG or in-mold graining.

The TPO thin film foil DecoJect™ is an ultra scratch-resistant decorative foil used for hard injection molded parts in the interior – as a low-cost alternative to soft-varnished injection-molded parts.

Benecke-Kaliko AG, with its headquarters in Hanover, Germany, is part of the ContiTech Group, a division of Continental. The company's

core area of competency is automotive interior trims. Benecke-Kaliko has four production sites in Germany, China and Mexico. In 2012, it posted sales of €357 million and employed nearly 1,700 staff.


With sales of €32.7 billion in 2012, Continental is among the leading automotive suppliers worldwide. As a supplier of brake systems, systems and components for powertrains and chassis, instrumentation, infotainment solutions, vehicle electronics, tires, and technical elastomers, Continental contributes to enhanced driving safety and global climate protection. Continental is also an expert partner in networked automobile communication. Continental currently has approximately 173,000 employees in 46 countries.

The ContiTech division numbers among the leading suppliers of a host of technical rubber products and is a specialist for plastics technology. The division develops and produces functional parts, components and systems for the automotive industry and other important industries. ContiTech has a workforce of approximately 28,000 employees. In 2012, it achieved sales of about €3.7 billion.

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The world has moved on apace since the days of the humble key, as Ian Adcock discovers

Arrival of the super-key

While many manufacturers persist in retaining what appears to be a conventional

blade type of key, with bitings to align within the lock cylinder, these are, more often than not, for the ignition lock with entry and securing the car electronically via remoteless key entry (RKE) or passive entry (PE) systems. Others, such as Renault, have simply abandoned keys, in favour of electronic cards that lock and unlock the car, and also initiate engine start up.

However, thanks to the relentless march of the microchip, the 'key' is now being embedded with additional functions. Earlier this year, for example, TRW integrated its first RKE/passive entry system with its direct tyre pressure monitoring system (TPMS) receiver functions to create a single

electronic control unit (ECU), making the systems more affordable in the process.

VALUE AND PERFORMANCE

"Integrating RKE and TPMS can offer enhanced value and performance," says Ken Kaiser, vice president, Global Electronics Engineering. "By eliminating the need for separate receivers for the two systems, we can maintain performance characteristics, use less space, reduce system weight and wiring complexity, and ultimately lower material and assembly costs."

This system is also leading the industry in reducing risks associated with radio frequency (RF) interference by utilising multiple frequencies. In-vehicle wireless communication systems have grown exponentially in the last few years, particularly since the federal mandate regarding TPMS in 2007. With such wireless

communication growth comes an increase in risk of RF interference. The use of multiple frequencies in this system ensures continuing RKE functionality, in the event that one of the frequencies is unavailable.

This technology change is transparent to vehicle owners, as there is no discernible change to the RKE key fob layout or performance – the transmitted commands are received by a single smart receiver/ECU that processes information from the RKE fobs, and also the temperature and pressure signals sent from the transmitters located in the TPMS sensor units in each individual tyre. The integrated ECU decodes the signals to activate the lock/unlock function for vehicle doors and the boot or tailgate, and provides tyre pressure warning information to the driver in the same way as conventional RKE and TPMS receivers.

Latching systems

“Designed to comply with governmental and insurance regulations, Delphi systems trigger an alarm when movement is detected in the vehicle’s interior.”

SUPERSLIM AND SPACIOUS

Continental, meanwhile, has launched one of the thinnest electronic car keys on the market. While most modern card-shaped car keys are usually more than five mm thick, the new key from Continental measures just 3.4 mm.

Where previous key cards were sometimes a bit of a struggle to fit into pockets, the new key card will fit into some wallets. Even the modern passive start and entry (PASE) system is integrated in the

to produce high-precision and delicate shapes.

PAY-BY-TOUCH

The new, slimline key card is also future proofed: in the medium term, innovations such as the display presented for the first time by Continental on the bi-directional key, which shows information about the current vehicle status, will be just as much a possibility as the integration of near field communication (NFC) technology chips. This technology is

to remotely switch on headlamps and interior lights.

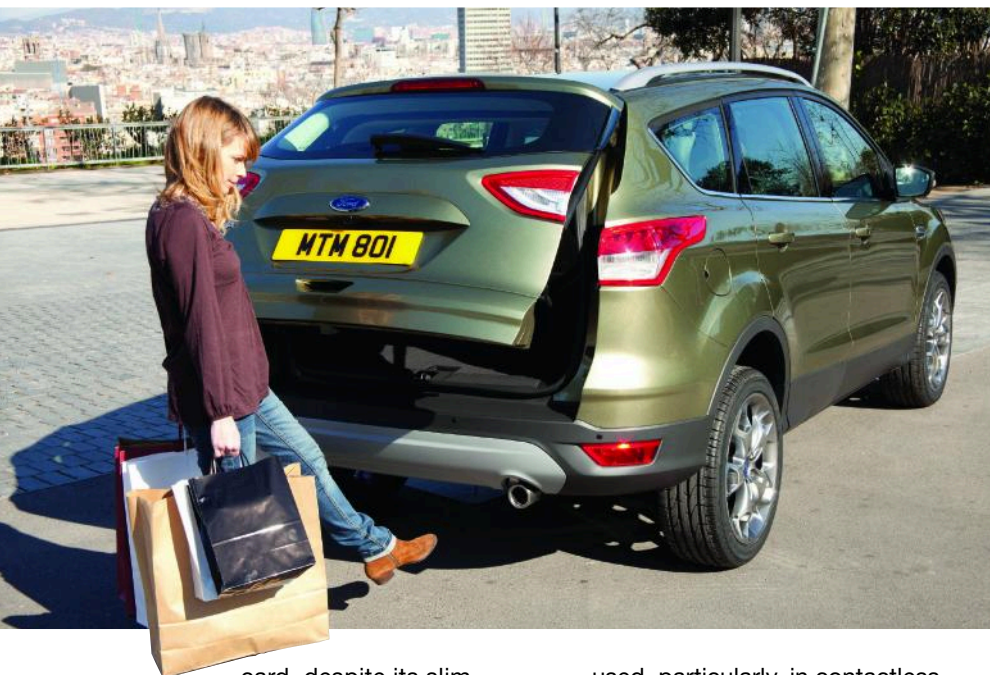
Delphi is also employing NFC in its Gateway Key Fob technology and Bluetooth interface, effectively acting as a range extender for the standard short range ‘phone interfaces.

Meanwhile Continental uses NFC sensors in the doors and cabin, which allow the owner’s smartphone to open the door and then start the car.

ANTI-THEFT BUILT IN

The latest security systems also make it more difficult for thieves to steal the vehicle. Delphi, for instance, offers multiple anti-theft systems, including interior intrusion detection systems, inclination sensing devices and battery backed-up sounders. Designed to comply with governmental and insurance regulations, Delphi systems trigger an alarm when movement is detected in the vehicle’s interior.

When equipped with an optional inclination sensor, the system also triggers an alarm when a change in inclination (lifting or tilting) is detected when an attempt is made to put the immobile car onto or into another vehicle to be transported away.



card, despite its slim dimensions.

The more than 20% reduction in material thickness has been made possible by using resin transfer moulding (RTM) for the first time, employing a special epoxy compound. This material doesn’t compromise the electronic components during the production process, while its excellent flow properties also mean it can be used

used, particularly, in contactless payment systems, so, if an individual’s credit card details are saved on the key, he or she can then pay for things simply by touching a sensor field on a ticket machine or at supermarket cash tills, for example.

These smart keys are particularly useful for lone women motorists when the car is parked in a dark location, allowing drivers





Where does the use of alternative materials in interiors go, asks Ryan Borroff

The inside story

The process to simplify interior systems and components, while adding value for both automakers and end users, is increasingly complex, complicated by the requirement to provide more innovative and more sustainable products – often with reduced mass and weight – while minimising process and material costs, and meeting end-of-life vehicle recycling legislation.

“When you talk about innovation...you can basically do three things,” explains Han Hendriks, vice president of Advanced Product Development Automotive Electronics & Interiors at Johnson Controls. “You can integrate functionality and take weight out. Or you can substitute materials [such as] carbon for steel. Or you can eliminate functions – just eliminate them – which is also a way...to take weight down. If you

combine that with new trends and expectations that consumers have for their future vehicle interference [and] appearance, [then] you’re also talking about new features and functions that you have to integrate, without adding too much weight or cost; or you try to take cost and weight out, while integrating new functions.”

Multiple approaches

The solution lies in material and design innovation to integrate components into as few components as possible. This can be achieved in a number of ways; in the manner in which different components are integrated or in reducing the amount of component material[s] by combining roles.

“The biggest surface areas in the car are the seats you sit on and the instrument panel (IP),” explains Andreas Wlasak, vice president

industrial design, Faurecia. “And the large materials that cover these structures; more and more of this real estate...is taken away by decoration...or has been downgraded by various functions of electronics, [such as] screens and unit fixed areas. This means there are three different industries – the industry of making large component parts [with] perfect surfaces on one side; electronics and human machine interface (HMI) on the other side; and, on the third side, the industry of wood and aluminium, and other decoration materials – all fighting for the same square centimetres of real estate in an interior.

“This battle is fairly new. It used to be the case that there were places assigned to each, with each pretty much distinct in the past. They’re not anymore; they’re getting more and more blurred. Design will be required to play a greater role in managing all



Opel Adam's 'starry sky' headliner (left) and trim library (above)

Material trends

three of those aspects by proposing clever solutions combining them.”

One area where this will happen is in-vehicle lighting. Recently, Johnson Controls developed the starry 'Planetarium' headliner in the Opel Adam. With 64 LED elements inset into the headliner material, the effect is a star-like twinkling in the roof, a feature that has only been available in much more luxurious, and expensive, vehicles until now. The same component offers five textile cover options and a variety of headliner designs, with dimmable lighting controlled via a unit integrated into the overhead console.

The light touch

The component was developed to use minimal energy – power consumption is just four watts – and the 'starry sky' within the headliner is less than 1mm thin. The component weighs only 200 grams, including

wiring. That's a lot of flexibility for a part offering an additional personalisation option to the end user and a further opportunity to add profit at the dealership.

Yet, according to Hendricks, future progress will see the ability to integrate the wiring and light sources into a component, so that it becomes, essentially, a single unit. “One example we're working on is printed light technology, so the light source is actually printed on a surface, instead of a separate component, and it's the same for wire harnesses and so forth,” he states. “We're looking at consumer needs and opportunities to enhance the consumer experience of the interior, but also looking at the manufacturing processes that allow us to address those needs, as well as take cost and weight out. It's called printed digital ink; or printed light.”

Suppliers including Faurecia and

Johnson Controls are looking at significantly reducing weight in the IP. This will involve not just substituting materials and designing specifically with new materials in mind, but also integrating functions and components.

“We're asking why can't this structure be the A-surface, when right now it's separate components?” says Hendricks. “We're also eliminating certain functions in areas where they require higher weight components or more components than in other areas.



Material trends



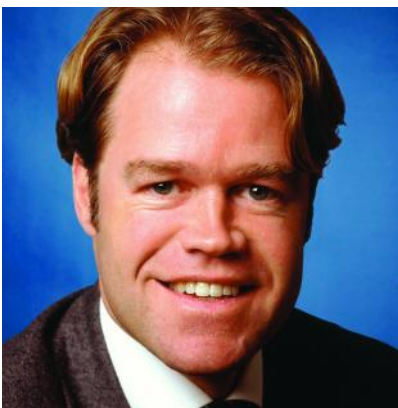
it's appropriate. You still need them to work on those materials and surfaces, so they're acceptable as a visible surface. It could also work in other areas, including seat frames, the centre console or the cross car beam that goes from one 'A' pillar to the other. These parts could be exposed. By making these parts visible...with a pure, honest, design where everything is no longer wrapped. From a weight-saving point of view, everything you wrap, you're adding a process step in terms of cost, and you're adding material, in terms of weight."

Thus far, the most obvious example of this is in the interior of high-end sports cars, particularly the cabin of the McLaren P1, which has taken its carbon fibre structure to the extreme of utilising it as an interior A-surface.

Strength and aesthetics

"Composites and fibre technology are really exciting, because, as these materials mature, it also allows us to integrate 'A' surface and 'B' surfaces, and structures in IPs and doors," says Hendricks. "A cross car beam and an instrument panel and air vents – that whole behind-the-surface functionality and structure that make an IP really heavy – combine that with the surface quality that carbon has and will have, or other fibre technologies, or multi-material composites that put strength in areas where you need it, and put more aesthetic qualities in other areas where you need that."

Ultimately, reducing complexity and weight, while innovating interior design, may be as dependent on new materials and changes in the manufacturing process as it is on the automaker's desire to hand over the management of such integration to suppliers. How far each carmaker is prepared to go remains to be seen, but it's clear that the interiors of cars will change significantly as the trend to lightweighting continues.



Hans Hendricks, vice president of Advanced Product Development Automotive Electronics & Interiors at Johnson Controls says they are looking at significantly reducing weight in the IP



What we've found is that weight equals cost. OEMs are willing to pay a premium when we take weight out. They've been saying this for a long time, but it's happening now because of CO2 emissions targets that they have to meet in the next decade."

Fresh alternatives

The next stage in this type of innovation will be the ability to integrate at a deeper level, combining the structural with the aesthetic. Ultimately, the drive to

weight reduction may see the boundaries between A- and B-surfaces disappear in certain vehicles, in specific areas of the interior. The result will be future interior forms becoming simpler, reduced, in terms of their underlying structure, and offering new alternatives when it comes to A-surface materials.

"Sometimes you have natural fibre materials that are structural in door panels and instrument panels," explains Wlasak. "So why not leave them uncovered in certain vehicles, if

Improve interior package design, increase vehicle safety, and ensure international compliance with the SAE H-Point Machine

A three-dimensional manikin that provides the physical representation of driver H-points, the **H-Point Machine (HPM)** is used to define and measure vehicle seating accommodations. Offering a deflected seat rather than a free seat contour as a reference for defining seat space, it is a vital tool in the design of interior packages.

Available through SAE International, the *HPM* is used in conjunction with SAE Standard J826 and is currently referenced in various federal and international regulations including NHTSA's FMVSS in the US and ISO standards. Utilized in testing for compliance to such regulations involving impact/crash, head restraint, or vision, it is the required safety certification tool for vehicle production in many countries around the world. Additionally, those who need to locate seating reference points and torso angles as reported by manufactures employ the *SAE H-Point Machine*.

And for advance design and research applications, the **HPM-II** is available, which includes reformed shells for a consistent and reliable fit in bucket seats, an articulating back for lumbar support measurement, and the ability to measure the H-point without using legs resulting in simpler installation.

Is one SAE HPM enough?
If your company tests and certifies to FMVSS 202a, it might not be.

NHTSA's head restraint regulation is now fully in effect. That means, in the US and Canada, front—and now rear seats—must meet FMVSS 202a. NHTSA is also encouraging the EU and UN ECE to adopt similar regulations.

To meet FMVSS 202a, a head restraint measuring device is attached to the SAE HPM. It is recommended in revised SAE Standard J826 Nov 2008 that a separate and unique HPM and HMPD for head assessment be used to eliminate any measurement variability that the HRMD may introduce.

Ensure North American compliance and be prepared for changes in EU/UN ECE regulations. Consider a second, dedicated SAE HPM—one for conventional HPM measurements and one for head restraint assessments.



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Something in the air

Just as we get to grips with the new PSA 'Hybrid Air' hydraulic brake regeneration system, cryogenic liquid air becomes the subject of a new report. Andrew English takes up the story

Cryogenic gas technology is well known. Nitrogen, a major component of atmospheric air, was first liquefied in 1883 and the short-lived Liquid Air Car Company of Boston, USA, produced a car capable of running on it in 1902.

Over a century on, however, cryogenic air could provide an answer to grid power generation storage requirements for renewable sources; be used to improve the efficiency of existing internal combustion engines; and also power a new generation of small urban vehicles, with zero tail-pipe emissions. The headline figures are that liquid air has the potential to

create a £1 billion a year industry, with 22,000 UK jobs in grid energy storage alone.

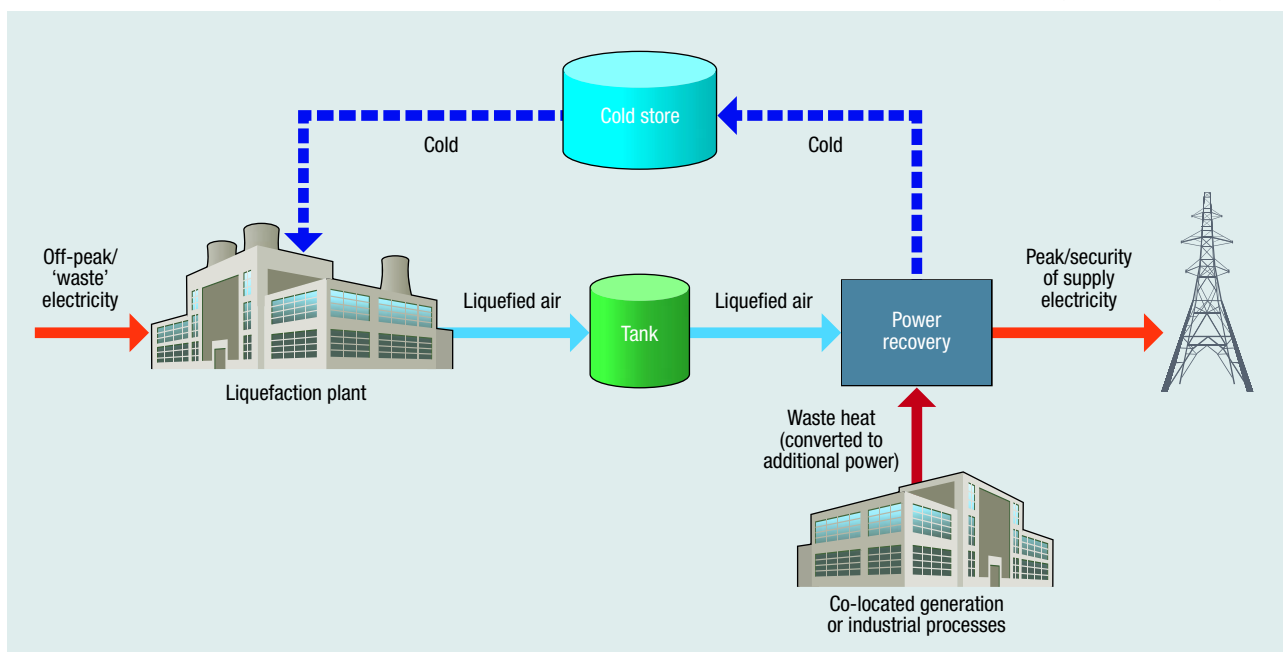
Into the future

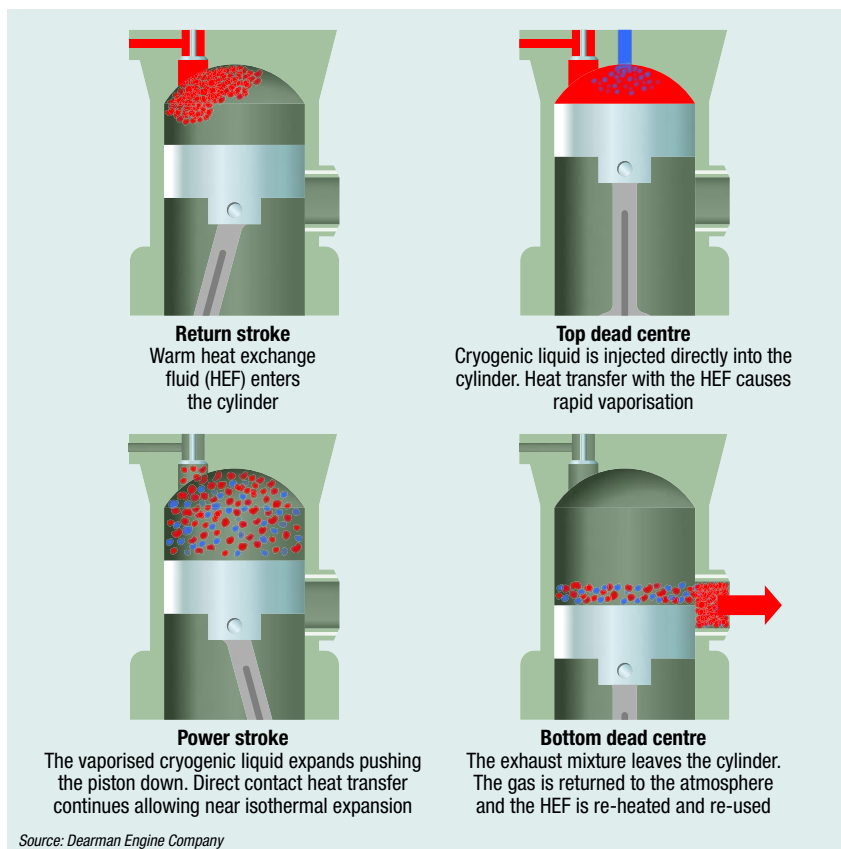
"Is this the time of the nitrogen economy?" asked John Leggate, managing partner of Quintal Partners, in his presentation at a recent conference at the Royal Academy of Engineering in London. It was a sentiment echoed by other speakers, but not all of them.

"It's really important not to overhype this technology," cautions Professor Neville Jackson, chief technology and innovation officer at Ricardo.

So, what is the technology all about? Liquid air is simply air cooled to minus 196°C by an industrial process of compression, expansion and heat removal. It is a blue liquid that is stored in a vacuum flask. One litre of liquid air is the equivalent of 700 litres of atmospheric air and, on release, the liquid boils, expands by 700% and returns harmlessly back to the atmosphere. It's that expansion that can be used to drive turbines or piston engines, such as the Dearman Engine.

It was Peter Dearman, a self-confessed "garden-shed" engineer, who hit upon the idea of injecting liquid air or nitrogen into the engine's





combustion chamber at top-dead centre, along with a small quantity of a heat-exchange (or 'thermal') fluid, which is generally glycol and water at ambient temperature.

This mixing of these two fluids, with their wildly different temperatures, causes the liquid nitrogen to boil and expand in the chamber, and drive a piston in a two-stroke cycle – or “one-stroke cycle, as there’s no compression stroke”, comments Michael Ayres, an engineer with the Dearman Engine company. At the bottom of the piston’s stroke, the exhaust port is exposed and a separate overhead exhaust valve opens, and the rising piston pushes the thermal fluid and air out of the engine.

Cryogenic injection

“I knew that, if you could expand the liquid air isothermally [at a constant temperature], it would be comparable to other energy sources,” said

Dearman. “And I knew that, if I could build an engine that used this principle, I’d be able to say, ‘that’s the bit I can do’.”

Intriguingly, the characteristics of this ‘cold-powered’ engine mean it can be used in a hybrid system with a conventional internal combustion engine to efficiently scavenge the low-grade waste heat, such as radiator heat, which is more or less irrecoverable with existing technology. That heat warms the ‘thermal fluid’ in the Dearman engine and increases its efficiency. In a split cycle engine, such as that proposed by Ricardo, along with Brighton University, for heavy truck operations, the introduction of cryogenic injection to the engine can scavenge waste heat in the engine and improve the

efficiency of the unit by up to 40% over that of the water-injected engine demonstrated in the 1990s.

Dr Andrew Atkins, Ricardo’s chief technology engineer, lists a range of other applications where the addition of a Dearman engine could improve efficiency. “It’s basically where you need to keep things or people cool, or run zero emissions,” he states. So the bus market, with its stop/start cycles, could harvest heat from the passenger cabin and primary diesel engine to help improve the efficiency of a Dearman-based hybrid system; similarly temperature-controlled transport where, say, the hot food would help power the Dearman-based chiller system.

Pilot storage plant

The promoters of the fuel, Dearman and its sister company Highview Power Storage, have already had a pilot storage plant operating in Slough, UK, and are working on efficiency improvements, using scavenged low-level heat.

Problems? As an alternative to fossil fuels, such as petrol and diesel, liquid air is a non starter; its energy density is worse than that of a decent lithium-ion automotive battery. There’s also the issue of boil-off from the vacuum flask, which will eventually drain the tank and, if it’s air that’s been liquefied, the fractionated boil-off can leave you with a tank full of oxygen, rather than air. “That’s a known issue and something the industry is used to dealing with,” says Atkins.

It’s an interesting idea, convincing technology and a pleasingly mechanical alternative to the

advanced batteries that are creeping across the industry. As I left the conference, the Technology Strategy Board had issued the requirements for a new series of projects in the area of grid energy storage. Liquid air proponents were licking their pencils at the prospect.



History in the making

Any concept car from Pininfarina is special. But, when it bears the name ‘Sergio’, it takes on a unique resonance. Ian Adcock talks with company chairman Paolo Pininfarina

“**Y**ou can imagine the level of emotion that is contained in this project,” says Paolo Pininfarina in the noisy confines of the Geneva motor show, “This is not a special car; this is a super-special car, because we wanted to put the best of us, the best of the team, of myself, to remember and celebrate the memory of my father. A monument for our company and for the collaboration with Ferrari.”

For 40 years, Sergio Pininfarina, who died aged 86 last July, headed the company founded by his own father, in that time creating some of the greatest cars of the last half of the 20th century and, in particular, for Ferrari.

Not only does this latest concept pay homage to Sergio, but it has

links back to the carroserie's founder, Battista ‘Pinin’ Farina, via the 1965 Dino Berlinetta Speciale that was the first car Sergio designed after Battista died.

THE PAST AND FUTURE LINKED

“The first car my father drove with just me in, and not with my mother and brother,” Paolo Pininfarina recalls, “was a Dino, so I am sure my father would have said, ‘Think of the Dino’, a mid-engined, light, compact, sensual car, based on the current Ferrari 458 Spyder.

“My father would have wanted us to reflect on the past, but use it to move forward. This car is not, deliberately, a design of a Ferrari of the future; this is a design exercise to celebrate a man, a father.”

It is also a showcase for Pininfarina's engineering skills and



aerodynamics know-how. The lack of a windscreen is not a styling whim to grab attention, but a serious study in the car's airflow and the creation of a virtual windscreen. Eliminating the windscreen would subject the occupants to increasing air pressure and turbulence as speed rises. The engineers and designers at Pininfarina designed, built and tested an aerofoil placed in a recess on the front bonnet, which produces a double deflection of the air flow entering the passenger compartment.

The first deviation is from the wing itself, the second from the air



Question time



"I think electric mobility will be more of a system than a product, where you share the service."

limited edition runs of cars, as he explains: "Maybe there is some future as a potential business model [for the Sergio] as a limited edition. When I say this, I am thinking of the business model of the 1930s and 1950s, working as a real carroserie with limited series.

"It's not just Pininfarina doing this, but Zagato is back to its roots; Bertone and Touring as well. We have the Italian carroseries exploring the past to make designs for the future through these limited editions: 10, 5 or 3 pieces for special clients that provide also the opportunity to do research and innovation, and make business at the same time.

"Otherwise, we only do pure concepts, which we have to sustain on our shoulders. There is demand for ultra-luxury from billionaires; there is a market out there. We want to be there for this market because we believe that we have 83 years of history - that is quite an important asset for our brand - so it's true there is a new demand from people carrying out this kind of investment, not only here in Europe and the 'States, but also in new markets."



that accelerates in the channel created between the aerofoil and the corresponding shape of the recess at the rear of the car. The result is that, thanks to the virtual windscreen, the air passes above the heads of the driver and the passenger, greatly increasing comfort and is effective at speeds as low as 50Km/h. This aerodynamic effect also contributes to increase the downforce on the car's front axle.

ENGINEERING SHOWCASE

"It's also a showcase for our engineering. Last year, we made the Cambiano concept that was the

showcase for interior and exterior design, and sustainable engineering, sustainable mobility with an electric range extender and so on. The engineering to my mind has to make it, the car, real."

Paolo Pininfarina has been instrumental in diversifying the company's portfolio, which now includes designing everything from trains and urban transport systems to Costa Coffee self-service espresso machines. But he is passionate about returning to the core business of hand-crafting

MARATHON CHALLENGE

For a company with such close links to what many would see as the acme of the internal combustion engine, Ferrari, Pininfarina has embraced electric vehicles enthusiastically through its partnership with Bolloré and the Bluecar it designed for the French manufacturer: "I am a fan of electrical mobility, but I understand that 4-5 years ago many people were too optimistic; it's not a race, it's a marathon.

"I believe that electrical mobility works and is sustainable, if you produce electricity in a green way from the wind and photo voltaic. But then you need to store the energy and distribute it at the right moment, to the right place."

Navigation: showing the way

TomTom is emerging as a leading contender in the field of embedded navigation systems for vehicles, as well as for brought-in devices such as smartphones, tablets and stand-alone navigators that can be transferred between vehicles.

At the Geneva Show, it announced it would be working with Toyota on their traffic service from 2014 and that Daimler will start using TomTom as from this summer. Meanwhile, it has extended its partnership with Fiat, as well as doing the head unit systems for Renault, Toyota, Mazda, Fiat, Lexus and Infiniti.

"OEMs see us as the connected navigation specialist. As consumer electronics is starting to blur with the automotive world, because of connected cars, and we see a lot of innovation with smartphones, people increasingly like the flexibility and content they have. They want companies like TomTom to bring that expertise into their cars, so they can create their own infotainment system and bring innovation from consumer electronics into the car.

"We see the smartphone's capability and capacity as a threat and an opportunity. I don't believe in a 'one size fits all' approach; across cars' ranges, there will be a combination of embedded and brought-in solutions. There are good reasons as to why an embedded solution is still the best and very relevant for the car makers. The OEMs have more control over the design and so the screen tends to be bigger, more focused on the driver. At the same time, a smartphone is a brought-in device and cannot be used while driving the car.

"I see augmented reality as an important trend. The future of navigation will be on multiple screens, while head-up displays (HUD) is a natural way to guide the driver. I believe it will cascade down from the luxury brands and, when the price of the technology falls, we want to support that. In the future, the windshield will be complementary to the embedded functionality; it won't be an either or. OEMs will offer a premium package for a higher price, including augmented reality for a safety package.

"Fundamental issues include keeping content and software up to date; it gets outdated very quickly. We've started latest map guarantee; just plug the navigator into your pc to update the maps. We're now moving into incremental map updates that we call 'fresh maps'. We're building an end-to-end update platform that's able to acquire latest map data through community input and can process that data in 48 hours, and give it back to the community in that timeframe. You receive over-the-air map updates relevant to your route. It's a cloud-based system; we don't always need to send a full map, but rather only send the delta for your route.

"We need more accurate mapping than today 2.5 metres now, but it needs to be below a metre within 3-5 years."



"Fundamental issues include keeping content and software up to date, it gets outdated very quickly."



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