ENGINEERING

proActive

The official e-magazine of Lotus Engineering

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CONTENTS

WELCOME

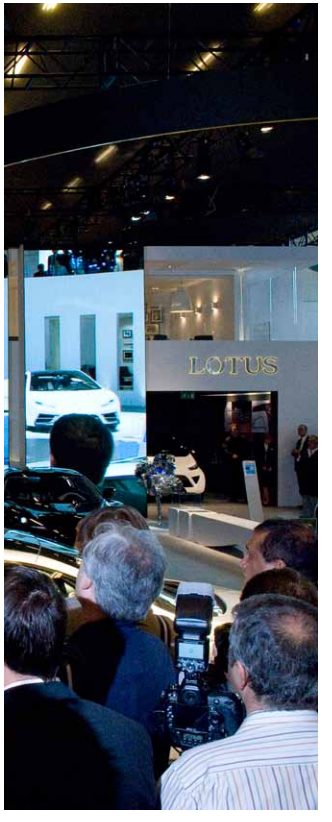
I do not believe I am exaggerating when I say that Lotus took the recent Paris motor show by storm. Unveiling a full range of five new cars, by any OEM's standards, is unprecedented. It was a clear statement of our intentions as we reinvent the Lotus brand.

Although the world may only recently have seen our exciting future, it is not new to us. Our five-year plan was in place some time ago and we are racing down the road to deliver it. Paris was an important early milestone, successfully achieved.

Understandably the media interest has focused on the future Lotus cars but a key part of the plan involves the continued expansion of Lotus Engineering's business. Naturally, Lotus Engineering will be instrumental in creating the new cars that will embody our brand DNA and demonstrate our excellence in lightweight architectures, efficient performance, electrical and electronic engineering and driving dynamics. However we are proud that our work for third-party clients has increased in each of the last four years and we are resolute in that trend continuing - it is a key part of our five-year plan. We are committed to helping our existing clients with our technologies and expertise and will expand into new market and technologies. We will grow.

Make no mistake; we know there is an enormous, exciting task ahead of us. We have a clear plan and it is a challenge we are relishing. >

Dr Robert Hentschel
Director of Lotus Engineering



INDUSTRY NEWS

JUST-AUTO EDITOR DAVE LEGGETT REVIEWS SOME OF THE QUARTER'S LAST NEWS HIGHLIGHTS

CHINA: Antonov has first customer for TX-6 gearbox

UK-based automatic transmission specialist Antonov says it has secured its first customer order for its new TX-6 automatic gearbox. It will be the first 6-speed automatic transmission to be built in China.

Read more

US: Quantum to supply solar roofs for Fisker Karma

Quantum Fuel Systems Technologies Worldwide says it has received a US$9.4m production release for the first production series of solar roofs for Fisker's Karma brand. Under the release, Quantum, with affiliate Asola of Germany, will initiate volume production of the solar roofs for the Karma in early 2011. Quantum claims the roof will be the "largest continuous and most highly curved" solar roof in a passenger car application.

Read more

JAPAN: Nissan mulling eco-pedal licence to other automakers

Nissan says it is evaluating the possibility of licensing its eco-pedal fuel efficient accelerator to other automakers. Nissan will potentially provide the relevant licence to Mikuni Corp, an auto parts manufacturer with which it collaborated on the design, for it to supply other manufacturers.

Read more

US: GM secures nearly 50% of 25,000 strong EV order from General Electric

It's a very, very big order. General Electric (GE) says it is to purchase 25,000 electric vehicles by 2015 for its own fleet and through its Capital Fleet Services business. GE will convert at least half its 30,000 global fleet and will partner with fleet customers to deploy a total of 25,000 electric vehicles by 2015. The company will initially purchase 12,000 GM vehicles, starting with the Chevrolet Volt in 2011, and will add other vehicles as manufacturers expand their electric vehicle portfolios.

Read more

BELGIUM: EC lauds largest ever passenger vehicle CO_2 fall

One of the consequences of Europe's scrappage schemes and the rise of small cars in 2009 is that average CO_2 emissions from new cars sold in the EU dropped by 5% last year – the largest annual fall ever recorded, a report published by the European Commission shows.

Read more

INDUSTRY NEWS

JUST-AUTO EDITOR DAVE LEGGETT REVIEWS SOME OF THE QUARTER'S LAST NEWS HIGHLIGHTS

UK: Component industry 'at critical point'

Speaking to members of the Welsh Automotive Forum, UK auto industry sage and academic Professor Garel Rhys warns that the UK's automotive components industry is at a critical 'tipping point' and could vanish by the middle of the decade without urgent action. It wouldn't run down gradually but, like a ship sinking, would suddenly vanish, says straight-talking Rhys. It's a sobering message and something that the UK government should perhaps take note of.

Read more

BRAZIL: Scania wins ethanol bus order

The city of São Paulo's mayor, Gilberto Kassab, announces that Scania ethanol buses will become part of the city's public transport system. The first 50 sugar buses will go into service in May 2011.

Read more

US: TRW wins new chassis control unit contract

TRW Automotive Holdings says it has won its first contract to supply an integrated driver assist system (DAS) and chassis control unit 'for a major European car manufacturer'. It would begin to supply the control units, known as the safety domain ECU or SDE, in 2013 for 2014 model year applications. The SDE integrates a number of chassis, suspension and driver assist system control functions and has the flexibility and processing capacity to integrate software from both the supplier and third parties including the vehicle manufacturer, using AUTOSAR as a basis.

Read more

LA SHOW: Mercedes shows 'compost car' concept

This was perhaps more science-fiction than 'news' but the Mercedes-Benz entry to this year's Los Angeles Design Challenge caught our eye. It's certainly a new take on what a truly 'green car' could, perhaps in a parallel universe, be. It is a biodegradable car manufactured from organic material.

Read more

US: British-built cars top J D Power satisfaction survey

I recall Nick Scheele telling me of his huge pride in Jaguar's showing in the JD Power quality surveys. It is still right up there. Cars made in Britain are increasingly popular with customers in North America according to the latest JD Power and Associates 2010 US Sales Satisfaction Index. Jaguar ranked the highest among luxury brands in satisfying customers with new-vehicle sales experience for a third consecutive year while Mini ranked top among mass-market brands.

Read more

INDUSTRY NEWS

JUST-AUTO EDITOR DAVE LEGGETT REVIEWS SOME OF THE QUARTER'S LAST NEWS HIGHLIGHTS

ITALY: Piaggio four-wheeler could target Nano and Smart

Piaggio, best known for scooters, has unveiled a four-wheel, three-seat concept vehicle which it said was "designed to meet mobility needs in areas with the highest development rates, specifically in India, Vietnam and South East Asia". Whoever styled this concept was no slouch. I want a go in one.

Read more

JAPAN: Toyota and partners set up battery nickel recycling

Toyota Motor Corporation (TMC), Toyota Chemical Engineering, Sumitomo Metal Mining and Primearth EV Energy (PEVE) announce the launch of what they claim is the world's first business to recycle nickel from used hybrid vehicle nickel metal hydride batteries for use in new batteries.

Read more

JAPAN: Honda thinks again in EVs

Well, you don't put all your eggs in one alternative powertrain basket do you? Honda, which for many years has been driving down the hybrid route, may be having second thoughts about demand for battery powered electric cars...

Read more

US: Siemens launches line of EV charging stations

Siemens Energy says it has launched a line of EV charging stations, which includes solutions for residential, public and commercial applications, including integration into the Smart Grid. The portfolio of EV charging stations is aimed at electric vehicle manufacturers, municipalities, corporations, fleets, utilities and residential customers.

Read more

TESLA MOTORS

US: Tesla inks Toyota powertrain deal

Tesla Motors says it has entered into a Phase 1 Contract Services Agreement with Toyota Motor Corporation (TMC) for the development of a validated powertrain system, including battery, power electronics module, motor, gearbox and associated software, which will be integrated into an electric vehicle version of the RAV4.

Read more

INDUSTRY NEWS

JUST-AUTO EDITOR DAVE LEGGETT REVIEWS SOME OF THE QUARTER'S LAST NEWS HIGHLIGHTS

JAPAN: Toyota turn to bio-PET for linings

Didn't VW use a pineapple-based material for its Brazilian-made Fox small hatchback's headliner? Anyway, Toyota says it is to introduce a new vehicle lining material that is made 30% from sugarcane to reduce fuel consumption. The new material, bio-polyethylene terephthalate, or bio-PET, currently used in PET bottles, will be employed as a car interior fabric for the first time in the world, the company says.

Read more

PARIS SHOW: Saab-BMW engine deal could herald more partnerships: Muller

Saab chairman Victor Muller says an engine tie-up with BMW could signal the start of other partnerships. "I am sure more will follow," he tells just-auto at the Paris show although he declined to reveal any specific partners he had in mind. "The transaction with BMW is the single most comforting transaction that we could have done - the number one premium player in the segment is now our engine supplier. This is a dream come true for a small manufacturer like us."

Read more

PARIS SHOW: Lotus stuns tous le monde with five new models

If you're reading this, you may be aware already...

Read more

PARIS SHOW: Jaguar shows jet-powered electric supercar

Also in Paris, Jaguar unveils an electric supercar concept, celebrating 75 years of the leaping car brand, that can reach 330km/h (205mph), sprint from rest to 100km/h (62mph) in just 3.4 seconds and accelerate from 80-145km/h (50-90mph) in just 2.3 seconds. The queue forms at the Paris motor show.

Read more

Jaguar C-X75 concept

LOTUS NEWS

NEW ENGINE RESEARCH PROJECT GETS FUNDING BOOST FROM THE TECHNOLOGY STRATEGY BOARD

The Ultra Boost project consortium has released details of an advanced research project to produce a new powerful, highly efficient concept engine. The Ultra Boost engine will use a novel pressure charging technique and advanced combustion system to enable a downsized engine concept that returns diesel-like fuel economy with gasoline levels of engine refinement.

The GBP2.2m Technology Strategy Board funding, which will be supplemented by the consortium partners to a total value of GBP4.2m, is part of the Integrated Delivery Programme (IDP) Competition for Low Carbon Vehicles. The Ultra Boost consortium is led by Jaguar Land Rover and includes partners: Lotus Engineering, GE Precision Engineering, CD-adapco, University of Leeds, Imperial College London, University of Bath and Shell.

Over the next three years the partners will utilise their collective skills and expertise in engineering, design, combustion modelling, fuel and lubricants to develop the highly pressure-charged, downsized engine concept that will deliver an expected 35% CO_2 tailpipe reduction compared to a V8 5.0 litre naturally aspirated engine while maintaining performance, emissions and transient response, and improving fuel efficiency. It is anticipated the first demonstrator engine will be available in 2011.

Lotus Engineering is providing the Lotus T6 engine management controller for the Ultra Boost project and optimising the engine management strategy for the Ultra Boost engine. Lotus Engineering will also be providing expertise in the modelling of the downsized pressure charged engine.

The project is being funded as part of the second competition run under the Technology Strategy Board's Integrated Delivery Programme, which aims to reduce carbon emissions from road based vehicles and accelerate the introduction of low carbon vehicles onto the roads for the overall benefit of the UK auto sector. >

Lotus Engineering partners with Jaguar Land Rover in the Ultra Boost consortium

LOTUS NEWS

NEW ENGINE RESEARCH PROJECT GETS FUNDING BOOST FROM THE TECHNOLOGY STRATEGY BOARD

The Technology Strategy Board alongside the Department for Business Innovation and Skills (BIS) and the Office for Low Emissions Vehicles (OLEV) has today announced funding for the next stage of its Integrated Delivery Programme (IDP) Competition for Low Carbon Vehicles. A consortium of automotive partners has been awarded GBP9.5m to expand and enhance technology for range extended electric vehicles (REEV) in the premium sector in a research project called REEVolution.

The consortium partners – Jaguar Land Rover, Lotus Engineering, Nissan Motor Co. Ltd, THINK, Axeon, EVO Electric and Xtrac – will contribute between them a total of GBP11million to the programme which, in addition to the competition funding makes a GBP20m project investment in the future of low carbon vehicle technologies. The consortium companies will collaborate over the next two years to develop advanced electric powertrains and a greater understanding of the commercial requirements needed for high performance electric and range extended electric vehicles. The work will accelerate the development of new technologies and key commodities while laying the foundations for a globally competitive supply base.

The REEVolution programme is the next phase of a previously successful project led by Jaguar Land Rover and involving Lotus Engineering called Limo Green, a series hybrid range extended electric Jaguar XJ. The project was part funded by the Technology Strategy Board, and the concept demonstrator delivered sub-120g/km tailpipe CO_2, had fuel consumption bettering 57mpg, a top speed of 180kph, an overall range of 600 miles and in Electric Vehicle (EV) mode, an impressive 30 miles. This new project will develop components and systems, as demonstrated on Limo Green, onto global levels of quality and reliability as required by production vehicles.

The REEVolution target is to deliver advanced Jaguar, Lotus and Nissan engineering demonstrator vehicles with a sub-50g/km tailpipe CO_2 emissions, which is typically a 70-75% saving over a similar vehicle with a conventional powertrain. These vehicles will benefit from technology developed by each of the

Lotus Evora 414E concept

consortium partners in the project and further the EV and HEV competency in the UK. The knowledge and results from this REEVolution project will also feed into the development of next generation components from the emerging UK supply base.

Lotus Engineering is responsible for the design and integration of two hybrid Lotus Evora demonstrator vehicles based around the Lotus Evora 414E concept and the integration of series hybrid vehicles for Nissan. Both the Lotus and Nissan vehicles will feature the Lotus Range Extender engine as part of the series hybrid drivetrain using the systems from other partners within the consortium.

The vehicles will include a highly complex drivetrain managed by the Lotus T6 controller with other systems to enhance the driving experience, demonstrating the expert capability of Lotus Engineering to integrate and develop advanced technologies for exciting and efficient hybrid vehicles. >

LOTUS NEWS

NEW ADDITIONS TO THE LOTUS LINE-UP

Lotus adds to expertise with two further appointments: industry leader Karl-Heinz Kalbfell and former Ferrari General Manager (EMEA), Guillaume Chabin.

With an unrivaled pedigree in the automotive industry, Karl-Heinz Kalbfell makes a welcome addition to the Group Lotus management team. Based at the Lotus headquarters in Hethel, Kalbfell, formerly of the BMW Group, will provide operational support and advise Group Lotus Chief Executive Officer Dany Bahar on the most efficient delivery of the business plan.

In addition to Kalbfell, Lotus has appointed Guillaume Chabin as Director of Sales. Chabin held senior positions at Ferrari and prior to this he was involved in the re-launch of Bentley.

Commenting on the appointments, Group Lotus CEO Dany Bahar said: "We are very pleased to have both Karl-Heinz and Guillaume on board. One of the keys to the success of any business is having exceptionally talented people working together effectively, and Karl-Heinz has incredible experience from working in extremely senior positions throughout the automotive industry to bring to the table - he has proven time and time again to have the qualities necessary to succeed in a difficult and fickle industry. His main role initially will be to bring together all our existing efforts across the departments and ensure that we are working effectively as a united force. It's not enough to have a great business plan on paper, we need to deliver and Karl-Heinz will play a crucial role in making this happen.

"Having worked with Guillaume previously, I'm fully aware of his capabilities – his business skills and understanding of the vision we have for Lotus complement our existing management line-up perfectly."

Karl-Heinz Kalbfell said: "I've been aware of Lotus over the years and like many in the industry, I have watched with growing interest as Lotus has developed under Dany Bahar and his team. It's not often that you get the opportunity to work with such an iconic automotive brand at such an exciting stage of its development and I really feel that now is the perfect time for me to contribute towards the future of Lotus. I have many years and some very demanding positions under my belt which allow me a lot of experience to draw upon. I'm ready for all the challenges that Lotus will bring."

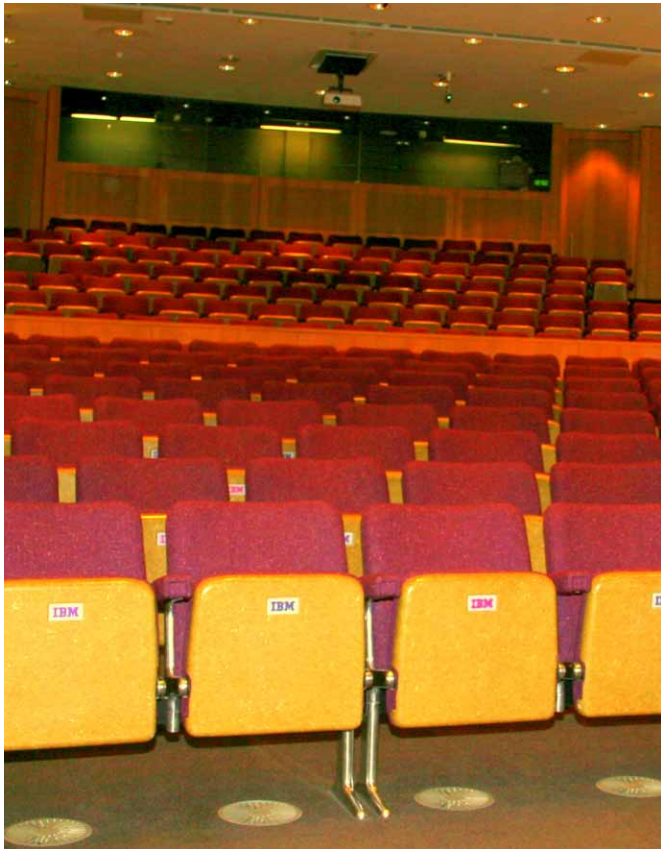
Commenting on his new role, incoming Director of Sales for Lotus Cars Guillaume Chabin, said: "Joining Lotus was an easy decision for me to make – having previously been involved in the re-birth of an iconic British brand when I was working at Bentley, I know the challenges and opportunities that lie ahead – this is a crucial time for Lotus and I'm very happy to be on board." >

LOTUS NEWS

LOTUS ENGINEERING BRINGS GREEN TECHNOLOGY TO IBM AUDITORIUM

Lotus Engineering has designed and built 250 natural hemp composite seat bases for the refurbishment of one of IBM's flagship lecture theatres. The composite components were made at Lotus in the composite tool room at the Hethel site, along side the Elise front crash structures and third-party composite project work.

The hemp that was used for the auditorium is grown locally in Norfolk, then processed to be used as reinforcement in a hemp-polyester resin composite. Once finished, the material properties of the hemp-polyester composite are similar to conventional glass fibre-reinforced plastic composites. The hemp composite was first used by Lotus in the Eco-Elise technology demonstrator that was displayed at the London motor show in 2008. >



LOTUS NEWS

GROUP LOTUS + RENAULT + GENII = LOTUS RENAULT GP

Lotus, the manufacturer, is back!

Group Lotus plc and Genii Capital have announced a partnership which will see the Renault F1 Team renamed as 'Lotus Renault GP' from the start of the 2011 racing season onwards. The association heralds the return of a highly successful Formula 1 association between Lotus and Renault from the 1980s. Lotus' racing pedigree and heritage coupled with Renault's technology in Formula 1 will set the united team on a path to future success.

Group Lotus plc will acquire a major equity stake in the team from Genii Capital. The transaction represents a partnership between Group Lotus and Genii Capital and signifies the beginning of a more comprehensive strategic alliance between the two organisations.

The partnership between Lotus and Genii brings the ability to quickly incorporate new technologies from F1 cars into Lotus road cars including hybrid technology, Kinetic Energy Recovery Systems (KERS), aero advancements and lightweight materials. Genii, an investment holding company with a portfolio of automotive technologies, bring non-F1 technologies such as lightweight braking systems, variable compression engine technology and on-board software systems to the partnership.

Group Lotus CEO Dany Bahar said: "I can think of no better platform for automotive brand communications than motorsport and F1. We're well aware that there has been a lot of controversy around the usage of our brand in F1 and I'm delighted to be able to formally clarify our position: We are Lotus, and we are back."

Dato' Sri Mohd Nadzmi Mohd Salleh, Chairman of Proton, Lotus' majority shareholder, said: "We know that Group Lotus has much to offer Formula 1 and vice versa. After careful consideration, we believe this arrangement will be fruitful, both from a commercial and marketing point of view."

Tun Dr Mahathir Mohamad, Proton advisor and former Prime Minister of Malaysia, said: "This is an exciting development which delivers strategic benefits to both Group Lotus and Proton. I fully support the partnership."

Carlos Ghosn, Chairman and CEO of Renault, commented: "This multi-partner alliance will bring a new dynamic to the team and enable it to compete with the sport's best from next season."

In addition to this, Genii is also offering Proton the ability to leverage on its existing business relationships in Russia and other parts of the world, as a means to expand Proton's global reach. Through Genii, Proton can also potentially access advanced automotive technologies by virtue of Genii's association with Mangrove, a venture capital group.

Gerard Lopez, founding partner of Genii Capital, said: "For Group Lotus, access to Formula 1 opens up new marketing opportunities and a major platform for business exchanges and development. In this regard, Genii Capital possesses shareholdings in, and direct access to, cutting edge companies in the automotive industry. Our tie-up with Group Lotus and Proton, which will enable its future road car ranges to take advantage of significant new technologies, is a natural step." >

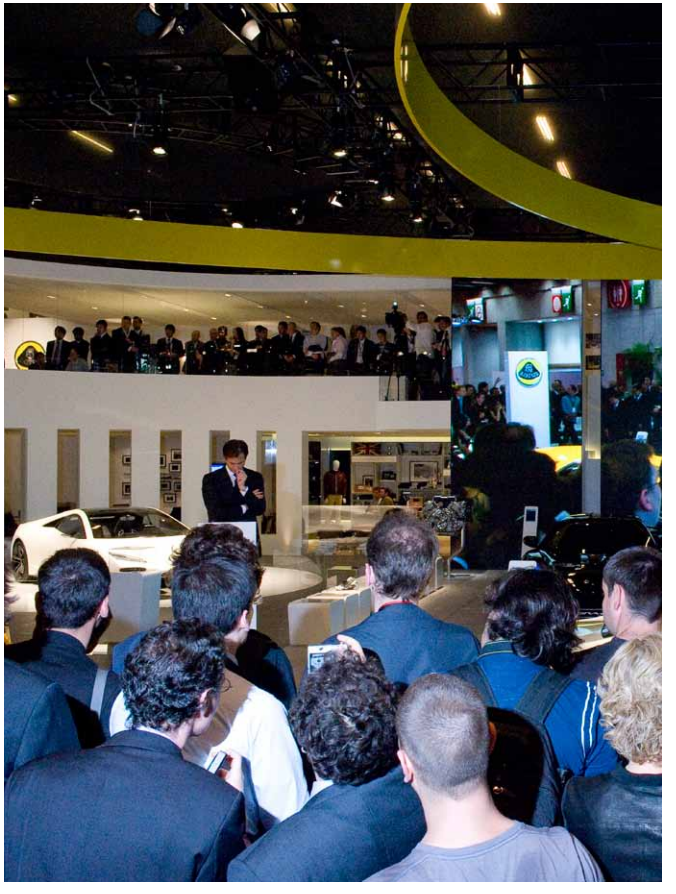
FEATURE

PARIS 2010 – A NEW ERA BEGINS

Lotus unveiled an unprecedented five new cars at the Paris Motorshow, reviving the evocative names; Esprit, Elite and Elan.

Lotus took the Paris show by storm making a clear statement of intent with CEO Dany Bahar's new vision for Lotus. The plan includes investing GBP770m into the business over the next ten years to develop the facilities and the five stunning cars scheduled to be in production by 2015. The new Lotus range includes exciting, new high-performance mid-engined sports cars along with Eterne, a four-door super-saloon, Elite, a front-engined GT with retractable hardtop and a replacement for the iconic Elise. Paris provided the backdrop for a lavish VIP preview event in the Louvre, with celebrities and luminaries afforded a special pre-show viewing of the new models. Dany Bahar introduced the prototypes to the world as they were driven along a specially erected catwalk between the guests. The evening charted the history of Lotus from the company's beginnings, with special appearances from Sir Stirling Moss and Clive Chapman, to the ambitious future plans. It was a spectacular event with glitz and glamour, dramatic videos and insightful speeches; however it was the cars that were the real stars of the evening. The Lotus press conference at the motor show echoed the razzmatazz of the Louvre event, hosted on an impressive two-floor Lotus show stand that paid homage to architects Anish Kapoor and Luis Barragán.

The press conference drew huge crowds of journalists eager to get an impression of what the new era at Lotus would hold. Dany Bahar again took centre stage to unveil the new prototypes, assisted by Lotus' celebrity friends: Naomi Campbell, Brian May, Mickey Rourke, Stephen Baldwin and Garou. Each of the cars was introduced by a stunning video displayed on screens the height of the stand with celebrity guests removing the covers to reveal the cars. It was a sensational event, leaving a lasting impression on those who attended, with many journalists reporting that Lotus stole the show. The Paris motor show gave Lotus the opportunity to introduce the newly set-up Lotus advisory board, which includes industry experts Prof. Dr. Burkhard Göschel, Bob Lutz, Tom Purves and Frank Tuch. The board has been put in place to share advice with Lotus senior management on areas such as product strategy, technology, quality, brand, marketing and distribution. Lotus has employed



FEATURE

PARIS 2010 – A NEW ERA BEGINS

the best people from across the industry, recently appointing two corporate heavy-weights, Stephan Pathenschneider and Wolf Zimmermann, joining Lotus as Chief Operating Officer and Chief Technical Officer respectively. These new appointments and the initiation of the Lotus advisory board give additional credence to the ambition of Dany Bahar's plan. The philosophy for the design of the five new cars is clear, each new car will match, if not exceed, competitors' sports and super cars in performance, design, technology and emissions. The cars will have high power to price and power to weight ratios, with futuristic, aggressive and sexy styling. The Lotus range will offer state-of-the-art car control systems, with optional hybrid systems and provide the owner with lowest-in-class emissions.

The flagship of the new product range is the Esprit, the ultimate Lotus, powered by a 620 PS mid-mounted supercharged V8 engine, with a top speed of 330km/h and a 0-100km/h time of 3.4 seconds it drives forward the Esprit legend. The Esprit is the quintessential super car

With neck snapping acceleration and jaw dropping styling, it is poised to be the pin-up car for the next generation. The Esprit will be the first car into production in 2012 with the Elan close on its heels in 2013. The Elan is a mid-engined sports car with a 450 PS, 4.0 litre V6 engine to give high octane kicks, but with everyday practicality and an optional 2+2 layout. The Elan is true to the brief, offering aggressive, sexy design with a stiff, efficient chassis and optional hybrid technology to reduce emissions and boost

From left to right, the new models: Elise, Elite, Elan and Esprit

FEATURE

PARIS 2010 – A NEW ERA BEGINS

The new Lotus Elise is due 2015

performance. Scheduled for production in 2014, the Elite is the first of the front engined cars; it is a true GT sports car with elegant styling and a retractable hard top, providing the perfect vehicle to cruise around the south of France. The Elite will use the same 5.0 litre V8 as the Esprit, with up to 620 PS available to give the 2+2 a 315km/h top speed and a 0-100km/h time of 3.7 seconds.

The legendary Elise will continue to be the entry level Lotus, with a stunning mid-engined 2-seater replacement on the way for 2015. The new Elise will be available with a 320 PS 2.0 litre pressure-charged engine to offer exhilarating performance and continuing in the spirit of the Elise it will be great fun to drive. To improve the ownership experience, the Elise will be a more usable sports car, with improved practicality and better ingress and egress. The aggressive, futuristic design is carried through the range with high-tech LCD displays and rear view cameras replacing side mirrors on each of the models. The Eterne is a front-engined super-saloon with the same pressure-charged 5.0 litre V8 engine as in the Esprit and optional four-wheel drive hybrid technology. The Eterne along with the Elite will offer full series hybrid capability with two electric motors to give the four wheel drive capability and a 40% improvement on CO_2 emissions. Along with the other cars, the Eterne will have the multifunctional Lotus steering wheel and an advanced transmission.

The five new models will take Lotus upmarket, with class-leading design, technology and performance at a competitive price point to take on rival sports cars. Lotus cars will move into a more exclusive sector of the market, restoring the brand to the levels it enjoyed in the past. There will be an increase in production output coupled with the wider range of vehicles returning to the super car market and entering new sectors

FEATURE

PARIS 2010 – A NEW ERA BEGINS

with the super-saloon and retractable hardtop GT.

This Lotus City Car concept was on display in the Lotus Engineering area of the stand, this concept car expertly blends the latest Lotus Engineering series hybrid drivetrain technology with Lotus Design sophistication. The Lotus City Car concept provides a showcase for Lotus Engineering's Electrical and Electronic Integration and Efficient Performance competencies, featuring an advanced series hybrid drivetrain with the Lotus Range Extender engine. Lotus Engineering will receive high levels of investment to grow capability, increase the third-party business, develop Lotus Engineering's existing facilities and establish offices in new markets around the world. >

The Lotus City Car concept

FEATURE

THE LOTUS INTERVIEW: LOTUS DIRECTOR OF DESIGN DONATO COCO

For the latest proActive interview with people at Group Lotus, Dave Leggett caught up with design director Donato Coco. Appointed in January 2010, Coco leads all Lotus Design activities for Lotus Cars and Lotus Engineering.

Dave Leggett: Can you give us a flavour of a typical day?

Donato Coco: My typical day starts between 8:00am and 8:30am at work and I look for an Italian coffee, but I usually cannot find it and settle for tea! I put a piece of white paper on my desk and I outline the tasks for the day and work out what has to be done with my assistant.

It is very busy; we have a lot to do. When I joined Lotus in January I found a team of 15 people; we had to quickly grow to 65 in order to meet the demands of the programmes for the models seen at the Paris Motor Show. We need to grow further in terms of numbers and resources...

DL: Are you personally involved in designing or are you mainly a manager? Do you get your hands dirty with design?

DC: I don't know of another way to do the job than to be deeply involved in design work. This is a job that is not a paper job and if you are not heavily involved, then you're not a director. I enjoy this life of car design very much.

DL: What is it about designing cars that inspires you?

DC: There are so many things, of course. But the personality of a company, the people who founded it, the values the company and brand represents – this is an exciting source of inspiration for me. As a designer you have to capture, to understand and to translate those values in a new and modern way. And every product is different and yet the components of the challenge are the same – a mechanical basis, of course, and you have to find a direction for the car's style. And I think the major inspiration comes from translating the personality of the company founders and values of the brand to the car. The car should embody that.

I worked for three major companies: Citroën, Ferrari and now Lotus. The three men, André Citroën, Enzo Ferrari and Colin Chapman were exceptionally creative and they inspire me a lot when I work.

DL: Those are clearly three very interesting and also very different companies...

The Elite nameplate is used for the first time since 1982

FEATURE

THE LOTUS INTERVIEW: LOTUS DIRECTOR OF DESIGN DONATO COCO

The newly revived Lotus Elan

DC: Absolutely, but the challenge in design is always the same. You're dealing with proportions, the creative process, art work, translating from two-dimension to three-dimension and at the end you have to give a sense of a well-designed product that fits the time and place, is original and yet reflects the values that it should reflect.

When you arrive somewhere, you have to think firstly about where you are before you pick up your pencil. You have to translate.

DL: With reference to Lotus, can you describe what you are trying to convey or translate into the design? What personality do you think Lotus has?

DC: To me, Lotus has a very British personality. It is perhaps a little eccentric – rock opera and philharmonic orchestra. When I see pictures of Colin Chapman, his appearance and moods, I believe his personality comes through in the cars, his energy and drive.

Lotus is deeply modern, because this company is moving very fast, but the essence of what it is about stays constant. The challenge is to be modern, competitive, aesthetic and pure – retaining core values like light-weight and agility in terms of the products. I am amazed that this company has remained so pure, that the positive image Lotus has built up has remained intact. Whatever has happened commercially over the years, in the public mind it remains something very essential, very light, very brave, very attractive.

When you design what do you have to take inspiration from? It has to be motivated more by the spirit than by the physical reality of what has been done before. The core values of a brand get you so far, but you need more than to just say 'lightness', for example. You need much more than that and you need to project yourself further...

DL: And the designer's personality is a key part of the mix?

DC: Always. And not only the personality but also the physical. I have always noticed that there is a relationship between the physical aspect of the designer and what he designs. And every designer will design differently and bring a different interpretation. We are all different, from different cultures, informed by different experiences, we have different reactions and so on – so the results are going to be different.

FEATURE

THE LOTUS INTERVIEW: LOTUS DIRECTOR OF DESIGN DONATO COCO

The legend returns - The new Lotus Espirit

It is like saying, is there a relationship between the writer and what he writes? Of course there is and it is the same thing in design.

DL: What do you see as the big challenges ahead for design at Lotus?

DC: Lotus Design is too small. We face big challenges as part of the new business plan. As I said, we have jumped to 65 people, but we now need to consolidate the situation and then grow further and we have to invest in order to deliver the cars that we have in our business plan. That is the main challenge ahead for Lotus Design.

And from the point of view of the products, the challenge is to adhere to the classic Lotus ideals – the handling, sports performance and so on – and to deliver that into the third dimension through the design. It is a great responsibility because the styling must translate and reflect those attributes. The key attributes and functionality have to come together through the design. And it's the design that is unique to Lotus and is inspired by the heritage and when you see a Lotus car, you can see that it is uniquely a Lotus. That is our considerable responsibility as designers.

We have to make better cars and better-designed cars that meet our customers needs. We have to change the capacity

FEATURE

THE LOTUS INTERVIEW: LOTUS DIRECTOR OF DESIGN DONATO COCO

of Lotus to deliver quality and quality is something that has to be born into the very beginning of the creative process, with the designer. It starts there when the designer picks up his pencil. And design is essential to the parts of the process further down the line – good design helps with assembly and so on. Good design should both simplify and be strong.

What are the challenges ahead? Evolve, grow, equip, invest and we have to make sure that our design corresponds to the spirit of Lotus. We have a great part to play. Lotus is an engineering company and the artistic element of design has always been a little at the back of the room. Too many activities have not been design-driven in the past. This is now changing and we must continue in that direction. Great engineering alone is not enough, you need to have great designs, too, if Lotus is to grow.>

The elegant lines of the Lotus Eterne

Donato Coco

Lotus Director of Design

Donato Coco joined Lotus Group as Director of Design in January 2010. He leads all Lotus Design activities for Lotus Cars and Lotus Engineering.

Donato Coco was previously Director of Design and Development – Ferrari where he worked on the Ferrari F430 Scuderia coupé and Spider 16M, Ferrari California, 599XX and the F458 Italia. Prior to Ferrari, Donato worked for Automobiles Citroën rising to the position of Chief Designer and was responsible for, among others, the Xsara, Picasso, C3, C3 Pluriel, C2, C1, ZX Paris Dakar and the Xsara WRC.

Donato Coco holds an MA in Automotive Design from the Royal College of Art, London, England. While at the RCA, he was awarded first prize in a design competition, which was presented to him by Margaret Thatcher when she was Prime Minister of Great Britain.

Donato Coco is an Italian national.

Donato Coco

FEATURE

COMPOSITE DEVELOPMENTS IN MAINSTREAM BODY STRUCTURES

Although steel has traditionally been the default material for the body structures of mainstream vehicles, there is an increasing trend within European OEMs to use composite materials in certain applications to reduce weight. One particular area where this is evident is the spare wheel well. It is an area of the vehicle where the requirement are more complex than they might initially appear and the approaches here might mark the way forward for composites in other parts of the body-in-white.

The spare wheel well, a common component on most passenger vehicles, is fundamentally a round or square depression formed into the rear floor, that holds the spare wheel, tools and jack. However, the spare wheel well must pass a number of tests, including the rear impact requirements for the vehicle; the wheel well should stay attached to the vehicle frame after a crash in order to control the movement of the spare wheel and its ability to absorb energy during a rear impact. Spare wheel well components are also subjected to a series of tests including NVH performance and durability.

When the move from steel began, the earliest composite spare wheel well developments tended to be made from sheet-moulded compound (SMC) or glass-mat thermoplastic (GMT) composite. Over time, GMT has emerged as the dominant composite technology for this application and the VW Phaeton, Audi A2 and A8, BMW X5 and Mercedes A,C,S and E class are all good examples. This is because it has the same types of benefits as SMC – lower weight, lower systems costs, lower tooling costs, and design flexibility – while also exhibiting faster cycle times, lighter weight parts and avoiding the brittle-failure problems. The tooling costs can be reduced by 75% compared to a steel solution. GMT materials also perform well in crash situations. GMT also allows design flexibility. Features and brackets can be designed into the part for items such as tools, jacks and batteries. Carpet can also be co-moulded onto the top face. The strength characteristics of the GMT can be locally tuned by adding unidirectional glass to areas of the mould.

Spare-wheel wells in composites instead of steel can provide a number of key advantages. First, tooling is simplified and less costly. Whereas it takes two or three steel stamping tools to make the deep draw shape of the wheel well, the shape can easily be created in composites with a single tool. As would be expected, the component weight can be reduced by using GMT.

A traditional steel wheel well

There are also design advantages. Because it is easier to form a tighter radius (sharper corner) in a composite part than a steel part, use of composites also can reduce packaging space required by 10-15%. This can free up valuable underbody or boot space for additional features or more storage. Although local heat shielding may be needed close to the exhaust, this can be a separate component or moulded into it. This higher degree of design freedom provides the ability to incorporate functionality such as rear battery trays, storage for jacks, tools and lockdown features. Additional benefits gained by switching to composites also include improvements in vehicle acoustics; plastics are 'softer' than metals and have better sound-damping properties, so

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noise is reduced and additional NVH material is not required.

The shift to composites does however have an impact on vehicle assembly. A vehicle with a composite spare wheel well normally requires a build sequence that enables the body-in-white to move through E-Coat without the wheel well in place, since the temperature of the solution is too high for the polymers typically used. Instead of being welded to the BIW, composite wheel wells are bonded with a PU adhesive.

Understandly weight or cost reduction will be the key drivers in changing the current material options of steel or GMT and Lotus Engineering, like others in the industry, is continuously striving to develop new material techniques and applications to optimize the parameters. One of the latest materials which shows great potential for weight reduction is self reinforced polypropylene (SRPP). SRPP is sold under several trade names such as ARMORDON, CURV, MFT, TEGRIS and PURE. This material also has the added advantages of being cost competitive and totally recyclable. A recent research project called Recycle was conducted by Lotus Engineering in conjunction with Propex Fabrics, Bi Composites, London Taxi, Trauma Lite, University of Warwick and Net Composites to assess the use of SRPP for A class and substructure parts.

Polypropylene is an ideal material for the automotive industry, with a low density and low cost. Traditionally polypropylene had to be combined with glass reinforcement to give it sufficient mechanical properties. SRPP is a polypropylene matrix, reinforced with high modulus polypropylene tapes. which is thermo-press formed and unlike GMT, it contains no glass so tool wear is reduced, enabling the tooling to be manufactured from aluminum rather than steel. With a density of 0.78-0.92g/cm^3, SRPP has the potential to provide a significant weight saving over GMT with a density of 1.5-1.8g/cm^3. Typical weight savings over steel are 25% for GMT and 45% for SRPP.

Such is the potential for SRPP materials in lower weight and cost ,that applications in areas such as spare wheel wells is an inevitable next step. And while this area of the body structure is generally overlooked, it is again likely to lead the way in the introduction of further composite technologies in other automotive uses from undertrays, body panels and roof panels. >

Author: Gavin Smith

A glass-mat thermoplastic (GMT) wheel well

FEATURE

FUEL EFFICIENCY IMPROVEMENTS USING VARIABLE VALVE ACTUATION STRATEGIES

The overall efficiency of engines continues to be improved, and one method of attaining this is to reduce the losses incurred during certain stages of operation. One major area in a four-stroke, spark ignition engine are the so-called pumping losses caused by using a throttle for part-load operation where the inlet air has to be pulled past a partially closed throttle. A method of reducing these losses is to run the engine with a wide-open throttle and use the inlet valves to control the engine load in a strategy known as early inlet valve closing, EIVC, thereby controlling the amount of air allowed into the cylinder.

Two single-cylinder research engines were used to investigate the savings that could be gained by using this method to control the engine load. The first engine was a conventional water-cooled, thermodynamic engine, used to measure fuel economy and emissions, while the second was an optical engine that could be used to measure what was happening in the engine cylinder and so help to explain the results obtained from the first engine. Photographs of the two engines are shown in Figure 1. The two engines were manufactured to be as close to a matched pair as possible and employed identical inlet and exhaust systems. The engines were capable of both port fuel injection and direct injection, but the results in this article will only concentrate on the direct injection measurements.

Three basic configurations of the engine were measured: throttled where the full valve lift was used; T-EIVC where both inlet valves were used but at a much reduced valve lift and duration; and S-EIVC where a single inlet valve was used also with reduced valve lift and duration. The two EIVC strategies employed generated a predominately tumble flow in the cylinder for T-EIVC and a swirl flow for S-EIVC, hence the T and S in the abbreviations. The S-EIVC can be further specified where necessary with the number 1 or 3 to denote the two possibilities of valve to be used. The valve profiles are shown in Figure 2.

One of the most significant benefits from EIVC strategies is the reduction in pumping work which leads to improvements in fuel economy. These are shown in the pressure-volume plots (Figure 3) where the areas under the 1-bar line can be seen as the work required to bring the fresh air charge into the cylinder. The work required by using valve control is substantially less than that required for throttle control.

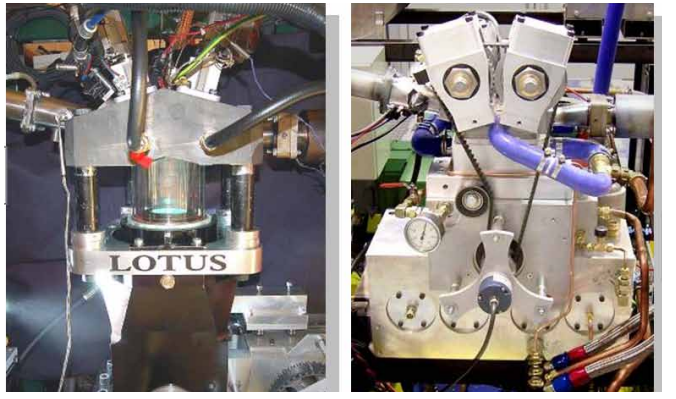

Figure 1. Lotus single cylinder optical research engine (left) and mechanical single cylinder engine (right)

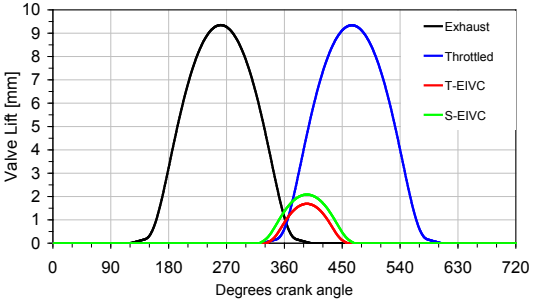

Figure 2. Valve lift profiles used in this work

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On the thermodynamic engine standard emission measurements of nitrous oxides, hydro-carbons and carbon monoxide were made along with specific fuel consumption, mass fraction burnt and engine running stability. The optical engine was used to image the injected sprays into the cylinder using flash lamps and a high-speed camera, imaging the combustion using the visible light from the flame and measuring the in-cylinder air velocities with a laser based technique called particle image velocimetry, PIV. The measurements on the optical engine were made to gain an understanding of the more conventional results obtained from the thermodynamic engine. One of the difficulties of EIVC is that the incoming energy supplying the in-cylinder motion stops once the valves are closed, and this can lead to this motion decaying very rapidly. As the mean air velocities decay, they transform into turbulence in the form of turbulent kinetic energy, which itself will also decay eventually into heat. This turbulent kinetic energy can be very good at enhancing the combustion, but if it has decayed before the time of ignition there can be a detrimental effect on the combustion. Therefore one of the objectives of this work was to try to control this decay and delay it long enough to be beneficial to the combustion process. Poor combustion can lead to a worse fuel economy, bad emission characteristics and unstable engine conditions that would certainly be perceived by the driver of a vehicle.

The graphs in Figure 4 show the fuel consumption for the engine running at the same part load under the three different valve strategies, including each valve used independently as a single inlet valve. The fuel consumption is plotted against the time of injection, which is a further important parameter for direct injection. The fuel needs to be injected early enough to allow thorough mixing of the air and fuel but late enough to prevent too much impact of the liquid jet on to the piston crown which can lead to higher hydro carbon outputs or even pool fires on the piston crown. The most obvious observation from the graph is the large reduction in fuel consumption when the engine is run with a wide-open throttle, and this is purely due to the reduction in throttling losses which we were hoping to see. It can also be noted that there is a latest time of injection that can be employed before the fuel consumption starts to rise, and this indicates the latest time

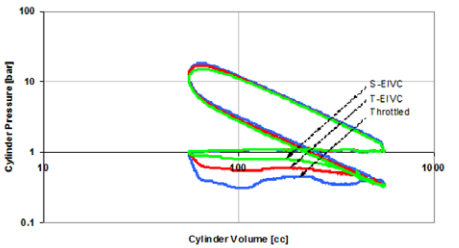

Figure 3. In-cylinder Pressure-Volume plots

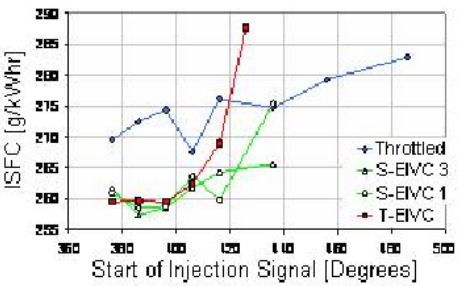

Figure 4. Fuel consumption

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that can be used to obtain good mixing of the fuel and air.

The fuel consumption shows the kinds of benefits that were hoped for; next it was important to check that these benefits weren't achieved at the expense of worse emissions. The data shown in Figure 5 show the exhaust-emissions for hydro carbons again plotted against the time of injection. Here it can be seen that the emissions for the unthrottled strategies are lower than those for the throttled case, which lends support for this being a good strategy to adopt. However the lower levels for the wide-open throttle cases is due to the lower fuel consumption for these cases, but it can also be noted that the single inlet valve cases are lower still and given that the fuel consumption is almost identical for all low lift strategies, another explanation is required. The most likely effect to cause this would be that there is a better combustion event for the single valve than the two valves leading to more of the fuel being burnt. The results for the carbon monoxide support this theory in that this emission is also less for the single valve, and the conversion of carbon monoxide to carbon dioxide is one of the latest reactions to occur and requires a good combustion event to happen efficiently. Finally, looking at the nitrous oxides in Figure 6, the opposite effect is noted between single and two valves in that now the two valves, low lift case has the lowest nitrous oxide emissions. Nitrous oxides require a high combustion temperature to form so these results suggest that the two valves case has a lower combustion temperature and for the same quantity of fuel present would again suggest a poor combustion event.

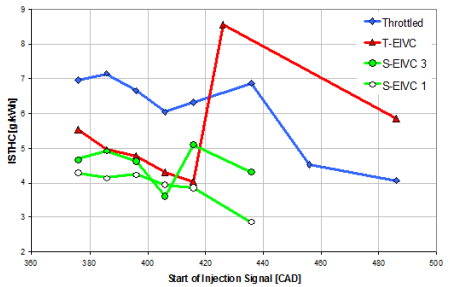

Figure 5. Hydro-carbon emissions

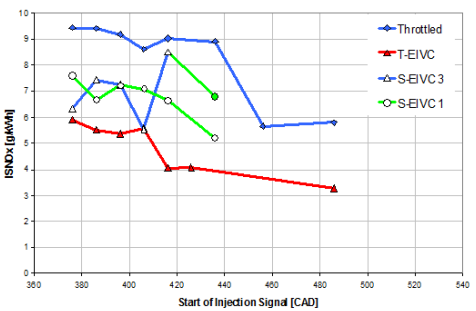

Figure 6. Nitrous oxide emissions

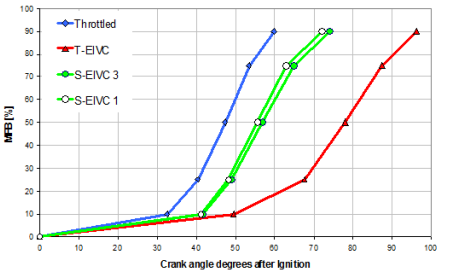

Figure 7. Mass fraction burnt

To check on the state of the combustion, Figure 7 shows the mass fraction of fuel burnt plotted against crank-angle degrees. The zero point on the X axis represents the time of spark and it has to be noted that this is not the same for all strategies, where the criteria here is to obtain the maximum in-cylinder pressure at about twelve degrees after top dead centre compression. The time from ignition to 10% represents the time for the flame kernel to develop and the full combustion

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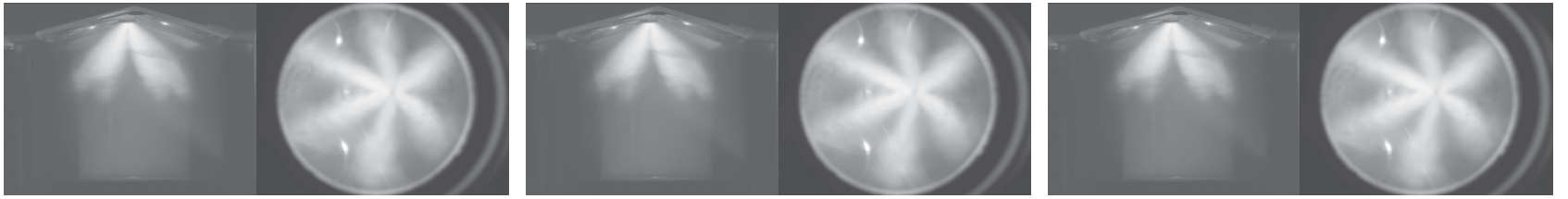

Figure 8. Spray images **a) EIVC Both valves on** **b) EIVC Valve 1 only** **c) EIVC Valve 3 only**

event to fully start and expand. It can be observed that this time is shortest for the throttled case and longest for the two valves, unthrottled case. For the latter, it can also be noted that when the full combustion starts it is much slower than all the other cases. This is now direct evidence that the combustion for this particular strategy is poorer than for the all the others and supports the explanations given for the emissions results seen earlier. There can be several reasons for this, one of which is the lower in-cylinder pressures and temperatures at the time of ignition leading to lower laminar flame speeds which are important during the kernel development part of the combustion. Other reasons for this require information from the results obtained from the optical engine, which will be covered shortly. It can also be noted that the covariance of the engine, which is a measure of its stability shows that the low lift, two valves strategy has the highest values and therefore the worst stability of all the strategies. This is almost entirely due to the poor combustion events observed in this case.

The first results to be studied from the optical engine are images of the spray as it enters the engine cylinder, Figure 8. The views shown here are all at wide-open throttle and low valve lifts, with the top images looking through the liner and the bottom images looking through a window in the piston crown. The greatest disruption of the spray due to the incoming inlet air is seen for the single valve 3 being opened, and it would be expected that the greater the disruption of the spray the better the air and fuel will mix. Inlet valve 1 shows the next greatest disruption with the two valve case showing a minimum and in fact looking very similar to images of the spray when it is sprayed into static atmospheric conditions. These results tend to suggest better mixing for the single valve than the two valves case which supports the results in terms of better combustion for these cases and gives some explanation as to what is causing it.

The other results from the optical engine are the measurement of the in-cylinder air flow fields. A series of these flow fields, in the horizontal plane, are shown in Figure 9, for each single

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valve and the two valve case, all for wide-open throttle and low valve lift, for a series of crank-angles during the inlet stroke. The first thing to notice is the different flow patterns generated by the two valve case, where there are two counter-rotating vortices, whereas the single valve generates a single large vortex. The two valve case is essentially a tumble flow and the single valve cases are swirl flows. The second point of interest is the greater magnitude of the velocities seen with a single inlet valve, and it is this that is responsible for the greater disruption of the spray observed for this strategy. The last point of note is that the two valve flows decay much quicker than the single valve flows, and this rapid decay and therefore formation of turbulence kinetic energy, leads to the faster decay of the turbulence energy, before the combustion starts, and so is not available to aid the combustion, giving a slow and inefficient combustion event.

Operating two engines for this piece of research has enabled the basic engine conditions and emissions to be measured, leading to information about the optimum strategy to be obtained. Additionally it has also allowed a greater understanding of what is happening in the cylinder leading to a deeper knowledge of how these strategies function and therefore a greater understanding of the in-cylinder conditions both before and during the combustion process. This invaluable understanding is highly important in the varied engine design and development activities we are undertaking for our clients. >

Author: Graham Pitcher - Lotus Engineering

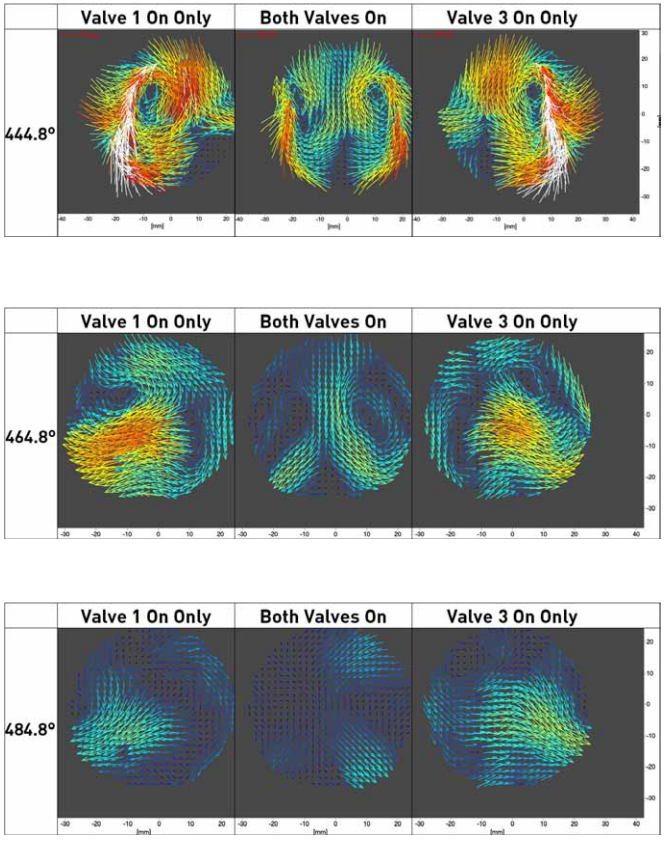

Figure 9. Mean PIV vector fields in swirl plane

FEATURE

Q&A WITH DICK ELSY, CHIEF EXECUTIVE OF TOROTRAK

Torotrak has developed expertise in the design and application of full-toroidal traction drive systems. Its portfolio of technologies is finding a wide range of applications, from Continuously Variable (CVT) and Infinitely Variable (IVT) transmissions for trucks, buses and off-highway vehicles, through to compact drives that enable emissions reduction technologies such as flywheel hybrids and variable supercharging. *just-auto* editor Dave Leggett caught up with chief executive Dick Elsy.

Dave Leggett: Torotrak's technology has undergone a lot of development and testing by the industry. Can you summarise the progress made in getting that technology evaluated and understood?

Dick Elsy: Torotrak has developed a family of technologies that are now ready for application engineering. Vehicle manufacturers and their suppliers see us as a clean tech company because our traction drive transmissions allow them to improve the efficiency of other systems.

Our fully-validated variable drive provides real-time management of speed and torque. Integrating it into other systems gives you more control over the flow of mechanical energy, so enabling new ways of controlling other systems more efficiently. Obviously the applications that concern people most are those that have the greatest impact on CO_2 and fuel economy.

Where we're different from a lot of the newer entrants is that our technology has had the benefit of a GBP75m investment and it is ready to apply. Most of our current technical development is being carried out with industry partners, mostly blue-chip businesses.

We've been fortunate in that Torotrak's core technology has benefited from the involvement of a broad variety of some of the industry's most talented engineers and measured against the highest possible standards.

In cars, our technology is an integral part of most of the flywheel hybrid KERS systems under development. We also have a joint venture with Rotrex to integrate a miniaturised version of our variable drive into a supercharger.

In the commercial vehicle sector, the economic argument for Torotrak's technology is very strong. We are working on main drive transmission programmes with a major European truck and bus manufacturer and with Allison Transmission Inc. For them it's the perfect solution. It's something that saves fuel by keeping the engine at optimum efficiency and is smoother and less tiring to drive, which is important to fleet operators.

Flywheel CVT installation

DL: Is it really the same technology in trucks and in flywheel hybrids and superchargers?

DE: It really is a single technology platform, but we have developed multiple versions with different levels of cost and sophistication to suit multiple applications. It is also fully scalable. Torotrak is focused on reducing transport CO_2 emissions and has built an organisation that brings together a broad range of expertise, sector knowledge and commercial experience. We see very clearly where the main opportunities for our technologies lie.

Improving the fuel economy of trucks and buses is an enormous concern for industry and society.

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Q&A WITH DICK ELSY, CHIEF EXECUTIVE OF TOROTRAK

The truck industry has not been able to enjoy the benefits of an efficient variable drive technology that can handle high power and torque – until now.

It has been stuck in a fixed ratio world where it is hard to truly optimise efficiency. Torotrak's variable drive technology provides a mechanically simple solution that helps to keep the engine running close to peak efficiency for more of the time.

In passenger cars, engine downsizing and brake energy regeneration have more potential. Companies are asking their engineers to look at how they manage vehicles' energy flows and there are some obvious wins. You can take energy from the exhaust, from the engine's crank or from the brakes and reinvest it in ways that provide significant CO_2 reductions.

Torotrak can help make each of these more efficient.

Variable drive superchargers and flywheel hybrids are cost-effective and relatively easy to package. In both cases, you need a simple variable ratio transmission to manage the energy flow efficiently.

DL: Torotrak is closely involved with several flywheel hybrid projects, all with different flywheel technologies. Which is the most likely to succeed in your opinion?

DE: Torotrak has been involved in developing its technology for flywheel hybrids ever since Formula 1 first started work on KERS systems. We are leading one consortium, Flybus, which looks at commercial vehicle applications. For that the flywheel attaches to an Allison 2000 Series transmission via the PTO, an architecture that could make retro-fitting the system to existing vehicles viable.

The fact that a bolt-on system costing a fraction of a full battery hybrid system could deliver fuel savings of 20% is pretty interesting. The response from industry and the public has so far been very encouraging with expressions of interest from big fleet operators.

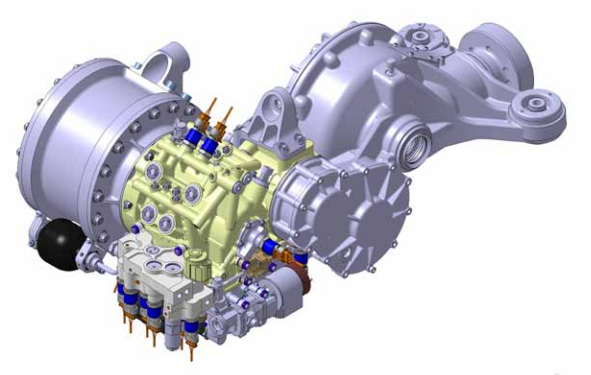
We're also involved in four others, two of which will publicly demonstrate the benefits in premium, high-performance vehicles as well as smaller, more affordable cars. The projects are different enough to make it impossible to compare flywheel technologies properly. All will deliver considerable efficiency improvements in their respective applications.

The only definite thing is that all flywheel-CVT hybrids need a variable drive. Torotrak's seems to be the technology of choice and we're building a lot of knowledge and experience around how to design and integrate the transmission in a commercially viable system.

DL: How good is the outlook for flywheel hybrids? Won't storing energy in a battery always be better?

DE: To take the last part of your question first, the internal efficiency of a mechanical KERS is superior to that of a battery-based system in which kinetic energy changes to electrical, then to chemical, then back to electrical and then back to kinetic. That's why the prospects for flywheel hybrids are so strong.

The signs so far are encouraging. We're aware of a number of



Flywheel CVT installation

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Q&A WITH DICK ELSY, CHIEF EXECUTIVE OF TOROTRAK

Flywheel CVT installation

vehicle manufacturers that have an active interest. Nobody has the money these days to throw at long-shot technologies. Hybrids are about recovering energy that's otherwise lost. The mechanical flywheels are very good at the harvesting and recovery of energy. They are much more power-dense, by which I mean powerful, than electrical systems which makes them more effective at energy recovery.

Battery-based systems can store energy for longer, but that's not the key requirement to genuinely save CO_2. There's also the issue of whole life costs with the battery based systems. The battery industry has yet to put up a convincing case that the batteries can last the lifetime of the vehicle and continue to deliver factory fresh performance. The flywheel hybrids can do this.

DL: How do you see demand for supercharging increasing in the future?

DE: There are very few diesel cars around that don't rely on some form of turbocharger to deliver the necessary power and torque. Gasoline engines are following a similar trajectory as they downsize to reduce fuel consumption. To provide higher torque across a broader operating range, manufacturers need some sort of variable compressor.

A conventional turbocharger struggles at low speed, particularly in smaller engines. Better low-speed boost can be achieved but the technology is complex and costly. The high gas temperatures in the exhaust of a gasoline engine make this challenge even greater. Supercharging is the main alternative, but the fixed ratio between engine and supercharger speeds means that if boost is optimised for low-end response, then energy is wasted at higher engine speeds.

We think that combining a miniaturised version of our variable drive technology with a supercharger is the smarter way of doing this. Because it's driven by the crank, not the exhaust, the temperature requirements are straightforward and the control is simpler and more precise.

DL: You formed a joint venture with Rotrex to this effect. Why? And what is the plan there?

DE: Rotrex is the world leader in centrifugal supercharger technology. Their system is compact, efficient, near-silent and has been used by some of the industry's leading companies. For some time it had been looking for a way of providing a variable drive capability and its studies confirmed that Torotrak was the leader in this field. It concluded that adding our scalable variable speed traction drive will overcome many of the compromises that affect current pressure-charging systems.

Our initial studies together indicated that volume-manufactured products that combine our technologies in a fully integrated unit will be very competitive. We've started prototype development and are engaged in early-stage talks with potential customers.

By co-investing with partners on areas that expand our technology's application range, we can bring developments to market more cost-effectively. Rotrak is a good example and I am sure there will be others.

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Q&A WITH DICK ELSY, CHIEF EXECUTIVE OF TOROTRAK

DL: On the financial front, how happy are you with the position of Torotrak?

DE: Torotrak is in a strong financial position. And, when you look at what is driving investment and growth in the industry, it's clear that Torotrak is well-placed. The company has substantial cash resources and there has been a substantial increase in investment in prototype and production-intent programmes by our customers and licensees. We now have significant revenue from engineering programmes.

We completed a strategic review last year that sharpened our focus and I know that our resources are focused on the customers, projects and applications that present the greatest opportunities for the business. This all makes me confident about proceeding towards production design and the realisation of per-unit royalties.

DL: Where do you see Torotrak in ten years' time?

DE: This industry is getting harder and harder to predict. Over the course of the next decade there will be greater global harmonisation of CO_2 regulations and targets. One thing that is for sure is that the industry is now fully prepared to invest in commercially viable CO_2 technologies. The industry is also happy to look at new technologies which deliver this – there's a much greater openness than ever before.

If we're serious about making transport sustainable and profitable in the world's growth markets, we will need simple, robust mechanical solutions. The challenge for vehicle manufacturers will be to devise strategies that give them the necessary cost and manufacturing flexibility.

I make no predictions for Torotrak, except that I believe small, innovative companies will become more and more important for Tier 1s and vehicle makers. Competitiveness in the automotive industry will demand specialist expertise and knowledge. Our continuing strength will come from focusing on the application of Torotrak's traction drive technology platform in carefully selected areas where it brings significant benefits.

Dick Elsy

Torotrak, Chief Executive

Dick Elsy joined Torotrak as Chief Executive in January 2003. Prior to this he was Product Development Director at Jaguar Cars during the time it was part of Ford's Premier Automotive Group. He previously spent 16 years at BMW/Rover Group where he held various senior engineering and commercial positions. He is a Chartered Engineer and a Fellow of the Institution of Mechanical Engineers. He is also a Director and Trustee of Engineering UK, a not-for-profit organisation promoting the benefits that engineering and technology can bring to society.

Dick Elsy

FEATURE

CONNECTING MAN AND MACHINE – THE HMI SYSTEM FOR THE LOTUS CITY CAR

In an increasingly electronic world, how the occupants engage with the vehicle is paramount. This is especially true of the niche and premium market, where customers have a desire for the latest technology to enhance the entire driving and owning experience.

People want more information than ever from the vehicle itself, while enjoying entertainment, better comfort and increased connectivity between the vehicle and the outside world.

One of the first displays to offer such functionality appeared on the Toyota Prius where the 'Multifunction Display' not only conveyed the energy flow during operation of the 'Hybrid Synergy Drive' but it also allowed operation of other vehicle systems such as in-car entertainment and climate control. Although useful for displaying hybrid drive modes and operation, the uptake of such displays is now becoming mainstream in conventional vehicles where additional functionality such as satellite navigation is being offered as built in rather than stand alone units such as Tom Tom or Garmin.

As our activity in hybrid and electric vehicles has rapidly expanded over the last few years, this has increasingly taken us into creating high technology Human Machine Interfaces designed to improve the way the user interacts with the vehicle. We have ever increasing experience in the integration of vehicle controls for improvements in functionality, design, cost and vehicle efficiency. This last point is particularly important for hybrid and electric vehicles where the intelligent car is driven by the need for energy management.

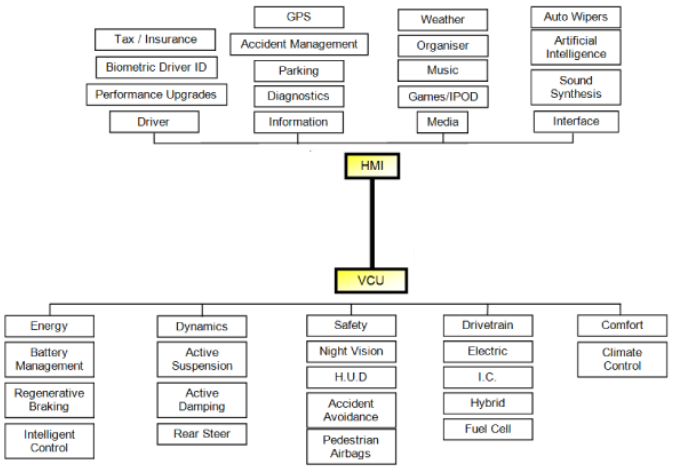

Figure 1: HMI & VCU schematic

The on-board energy storage for these vehicles typically includes a battery pack that not only provides energy for the vehicle drivetrain but also energy for the other vehicle systems. To get the most out of the energy storage, an integrated approach is paramount to effectively manage the energy usage thereby maximising vehicle range. The HMI is the direct link with the vehicle control unit (VCU) that manages the functionality of the vehicle systems. This functionality is setup by the driver programming in certain parameters via the HMI. Figure 1 gives an indication of the functionality that can be user-defined on the HMI side and the corresponding vehicle control functionality provided by the VCU.

Lotus Engineering has created HMI systems for both Lotus products and also for many hybrid or electric demonstrator vehicles. In many cases, these have been single panel, touch screen displays but more recently, additional functionality has been brought about by having multi-panel display solutions.

The simple panel solution from the EVE Hybrid a few years ago was developed for a parallel hybrid demonstrator vehicle and housed in a rapid-prototyping binnacle. There are hard-wired buttons underneath the display

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that are used to force the hybrid drivetrain to run in certain modes such as stop/start, EV only or full hybrid. The display itself, is a touch screen and in normal mode, shows the energy flows during vehicle operation. Sub-screens can be accessed to further interrogate the system to get information such as battery state of charge.

For another electric vehicle, Figure 3 shows an HMI that in normal mode, displays motor torque, battery pack current, voltage and state of charge and motor coolant temperature. Warning tell-tale symbols are also included. The interface is also touch screen to access sub-menus and pages but in this case is more as an engineering development tool rather than to control additional vehicle functions such as In Car Entertainment or Climate Control.

More recently, the systems in the Lotus City Car concept incorporated many of our latest ideas. Figures 4,5 and 6 show an HMI that has been created for a series hybrid application and this latest development now brings in the integration of other vehicle systems as well as a new approach to touch screen functionality.

The system comprises a CAN Bus interface to receive vehicle information and three 7-inch LCD screens for infotainment, instrument panel and the main touch screen interface

The new concept has developed an interface where the touch screen works as a keyboard and the infotainment screen is the monitor. The main problem with having just one touch screen for interface and display functions is that your hand is generally in the way so you can't see what you're doing. This new concept however, allows for a large-sized keyboard to be shown which is unlike other touch screen devices that hide half of the screen with an onscreen keyboard.

By separating the interface and display screens, the HMI is much more user-friendly to operate, particularly now that it encompasses a lot of the control functionality of the vehicle systems.

It is important to have some of the controls constantly showing and always in the same position so that they can be used easily. A good example of this is the ambient temperature readout and climate control.

The instrument panel has all the expected information you would find on a normal car but includes a gauge for battery level. The section inside the

Figure 2: HMI for parallel hybrid vehicle

Figure 3: HMI for Pure Electric vehicle

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The Lotus city car concept

speed gauge shows where the energy propelling the car is coming from. The purple circle and associated images on the left hand side of the gauge indicates energy being used from the range extender and the blue circle and associated images to the right is energy coming from the battery. The outer circle also changes in size depending on the amount of energy being used. This balance would constantly change while the vehicle is being driven so this display would show energy flow in a similar way to the earlier examples of displays.

The infotainment system includes radio, video and MP3 player, satellite navigation, telephone, web browser, general system set-up, and hybrid operation status and trip information. Another feature that will become increasingly important is smart journey planning. We are all used to inputting journey details into a satellite navigation system and the system calculating the shortest or fastest route. To take it a stage further the system will interrogate the on-board energy storage, be that a battery pack, fuel in a tank, or stored kinetic energy, and the functionality of the system would enable the smartest or best usage of the energy available. For example, if the journey were short and there were enough charge in the battery, the journey could be completed in EV only mode. Additionally, if there were an incline, the hybrid control strategy could be adjusted so the battery pack is at full charge for climbing the gradient.

Looking to what will come next, smart journey planning can be linked to 'vehicle-to-vehicle' (V2V) and 'vehicle to grid'(V2G) communications, locations of charging points or refilling stations and traffic management systems. Smart climate control systems can be linked with weather reporting over an internet connection. Accident avoidance can be delivered from on-board vehicle systems such as lane departure and radar-based cruise control and also off board systems such as V2V and V2G communications. The world of automotive electrical and electronic integration is fast-moving and as we expand further beyond our core expertise in hybrid and electric vehicles, it is an exciting place to be. >

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