Delphi puts on the brakes

Delphi used new CAE/CAM methods to develop its Advanced Disc System (ADS).

A new braking system has been developed in Europe by **Delphi**. Called the Advanced Disc System (ADS), it uses twin-disc technology, replacing the conventional fixed disc and floating caliper with two floating discs and a fixed caliper, to give what Delphi claims to be a "very high" specific torque capability, and substantial improvements in thermal management that can lead to benefits in weight, packaging, and NVH (noise, vibration, and harshness).

"The traditional solution to cope with increasing vehicle weight and performance is to uprate conventional braking systems, including larger discs (which may often necessitate larger wheels) and to use advanced materials," said Chris Baylis, Director of Engineering at Delphi's Braking Innovation Center in the UK. "But this [design] is a costly solution that has a negative impact in many other areas of vehicle engineering. ADS helps to solve those problems, and is the first significant change in base braking technology since the first volume application of disc brakes some 50 years ago." Disc brakes were first available on the 1950 **Chrysler** Imperial, fitted to the **Citroën** DS in the mid-1950s, and on the **Jaguar** XK150 by 1957.

ADS uses two discs floating on the outside diameter of the hub. A hydraulically actuated piston applies braking force via pads that operate on the outside and inside faces of each disc, providing four friction surfaces. The system can therefore provide up to 1.7 times the torque output of a conventional single disc system of the same effective diameter, or similar torque from a reduced diameter. "Wear and serviceability are equivalent to today's traditional product, and the floating disc architecture eliminates problems with lateral run-out," said Baylis.

The twin-disc design also provides four cooling surfaces, without the need for vanes or cooling channels, substantially reducing thermal stress on the brake and hub-mounted components. This improved thermal management provides engineers with many options for enhancing other aspects of the braking system. By greatly increasing opportunities to optimize the combination of disc size, pedal travel, booster size, and friction material, ADS allows the feel, cost, and performance of the system to be precisely matched to market requirements, according to Delphi.

With four pad surfaces, ADS requires approximately half the apply-pressure of a conventional disc brake. This could be used to significantly downsize the vacuum booster or to reduce the pedal effort and travel. A downsized booster could reduce mass by up to 1 kg (2.2 lb) and provide more underhood space to improve packaging flexibility. Alternatively, disc diameter could be reduced by up to 25 mm (1 in), allowing smaller wheels, higher aspect ratio tires (for off-road vehicles), and a significant reduction in unsprung weight.

"Because the discs are floating on the hub, their contact with the pads is always even," said Baylis. "ADS doesn't have the wear issues or the tolerance stack-up that can cause judder and squeal in conventional systems."

The thermal management capabilities of ADS, and its minimal generation of disc thickness variation—caused by the discs wearing unevenly—is said to aid NVH performance, helping to reduce noise-related warranty claims that surveys show are a major consumer issue in the U.S. and the cause of significant warranty costs.

Other benefits of the system are claimed to include reduced brake fade and—due to the reduced apply-pressure—shorter stopping distances in the event of a vacuum failure, a homologation requirement that can be increasingly challenging to meet when using conventional highly boosted systems. The new

system has been tested to the independent **AMS** (Auto Motor und Sport) standards using a **BMW** X5 to which it was fitted. In the 12-stop test, increasingly seen as a European standard, the vehicle demonstrated a "no fade" performance, reported Delphi.

The company says that its testing indicates that in a typical high-performance SUV application, ADS will remove the need for several brake-system specifications, reduce the maximum operating temperature by more than 100°C (180°F), improve refinement, and offer either reduced pedal travel by up to 25 mm (1 in) due to the reduced volume of fluid required for actuation or booster downsizing by around 40 mm (1.6 in).

Briefs

TIAX has been awarded a contract from the **U.S. Department of Commerce**'s National Institute of Standards and Technology to help advance the development of solid oxide fuel cells (SOFC). Current SOFC designs have the potential to deliver a clean source of power, but have a low tolerance for thermal cycling. The first phase of the project is to identify new materials with appropriate thermal characteristics for a fuel cell.

Vetronix Corp. and **Injury Sciences** LLC have extended the strategic partnership that pairs the Vetronix CDR (crash data retrieval) system with Injury Sciences' WrExpert software. WrExpert assists insurance professionals in analyzing the severity of vehicle collisions. Vetronix CDR downloads pre-crash and crash data from a vehicle's airbag module to a laptop computer. The first version of the CDR system was developed in cooperation with **General Motors** and contained capabilities to extract data from GM vehicles only. The latest software release was developed with **Ford** Motor Co. and adds communication with Ford's advanced Personal Safety System-equipped vehicles.

The **Texaco Ovonic Fuel Cell** Co. was a joint venture formed in September 2000 between **Texaco Energy Systems** LLC (TES) and **Energy Conversion Devices**, Inc. (ECD) to develop regenerative fuel-cell technology. ECD has now acquired the interest of TES, and the company will be renamed **Ovonic Fuel Cell** Co. LLC. Current efforts are focused on building fuel cells for portable and stationary applications, and continued development of the technology for transportation. ECD and TES continue to support two additional joint ventures in nickel metal hydride batteries and solid hydrogen storage technology.

Pininfarina S.p.A. has completed negotiations with **Lagardère** SCA regarding the purchase of **Matra Automobile**'s engineering, testing, and prototyping businesses. The acquisition, which is still subject to regulatory clearance, will strengthen Pininfarina's automotive design, engineering, and niche manufacturing capabilities.

Twin floating discs are a key feature of the ADS from Delphi.

Total vehicle mass saving could be as much as 7 kg (15 lb), depending on system specification and the level of integration.

The system has completed more than 1.5 million km (0.9 million mi) of tests in 20 vehicles to help ensure that it will continue to perform to specification in any terrain or usage pattern throughout a vehicle's life. Two fully engineered implementations have been shown to vehicle manufacturers, one fitted to a B-segment small European car, the other to a large, high-performance SUV. The former has the piston integrated within the suspension knuckle while the latter demonstrates a stand-alone piston architecture that could be implemented as part of a mid-life model upgrade.

ADS can be manufactured using existing materials and processes, and Delphi says that it has closely examined ways in which cost and complexity might be further reduced. An example is the wheel hub on which the discs are mounted, which is designed as a one-piece unit into which the wheel bearing can be press-fitted. Future developments will introduce additional lightweight materials, leading to further weight savings.

To help vehicle manufacturers implement ADS, Delphi has also developed a suite of computer-based analysis programs that model a range of vigorous whole-vehicle tests, allowing designers to quickly optimize the combination of benefits achievable with the system.

Delphi believes ADS could be in production by 2006, and it can be delivered as a separate product or integrated with complete vehicle corner modules and supplied using the latest SILS (Supply In-Line Sequence) techniques. ADS can also be integrated with other systems from Delphi's portfolio of electronically controlled brake technologies. "Conventional brakes struggle to react against the torque of increasingly powerful engines, so stability programs have to be calibrated to shut the engine down early at the expense of refinement and driving pleasure," said Baylis. "ADS will allow vehicle manufacturers to make the operation of these systems more transparent."

Stuart Birch

Color glazing from Solutia

The use of colored glass as a design feature for enhancing the ambience of car interiors is getting more popular, particularly in northern Europe. It can lighten the interior and provide the car with added aesthetic appeal, particularly if the glass is subtly colored. The U.S. company **Solutia** Automotive, which has a technical center and production facility in Belgium, is now supplying its Vanceva glazing system to **Porsche** for the roof of the 911 Targa, **Peugeot** for the 206 Roland Garros roof, and **Land Rover** for the Discovery Commercial's rear side glazing.

The Porsche 911 Targa uses the Vanceva glass system for its roof.

The Vanceva glazing system, which uses colored interlayers, can also be used for windshields and is available in different light transmission specifications. Vanceva has been chosen for several concept cars, including the **Ford** Faction Concept SUV, Ford GT, and **Saturn** Sky.

According to Andy Thackray, Solutia Automotive's European Market Development Manager, the technology will be applied particularly for low volume or limited edition production. "It is also a way to make an ordinary car look far more glamorous," he said. "Several production and concept cars will soon be added to the list of users."

Vanceva's colored plastic interlayers are bonded between two sheets of glass under heat and pressure. This feature gives an added security element—the glass adheres to the interlayer even when struck forcibly. The standard color range is wide and includes bronze, blue, green, and gray, but designers can use the Vanceva Color-Custom system to create subtle colors specific to a marque or to color-match with a vehicle.

The Vanceva system incurs no weight penalty compared to standard laminated glass, and laminated glass itself weighs some 10% less than standard toughened glass of the same thickness.

Stuart Birch

GM small block gets three-valve head

General Motors has proved the value of modern overhead valve (OHV) engine design with its Generation III small-block V8 engines, and the forthcoming Generation IV engines will continue to advance the architecture once considered obsolete. But GM Powertrain recognizes the inherent handicaps of a two-valve per cylinder head design that is typical in OHV engines. To further extend the life of the Generation IV V8 and its revised High Value V6 engines, the company has devised a three-valve head design to work with these pushrod engines.

Adding a second intake valve improves intake air flow, which provides some value, but perhaps more importantly the design relocates the exhaust valve and the spark plug within the combustion chamber. The exhaust valve moves from alongside the intake valve to the other side of the cylinder, so less exhaust heat transfers to the intake port. The resulting cooler intake charge boosts power and efficiency.

Positioning intake and exhaust valves on opposite sides of the combustion chamber leaves space in the center for the spark plug, which improves combustion efficiency. Together, these improvements boost power output by 10-15%, according to the company.

A short, nearly horizontal pushrod (orange) links the intermediate rocker arm located on the conventional rocker shaft to the stud-mounted rocker that opens the exhaust valve. A forked rocker arm operates both intake valves.

The three-valve engine has the intake valves in a straight line, operating them with a forked rocker arm off a conventional rocker shaft. Because the exhaust valve is on the other side of the spark plug and is not mounted in the same plane as the intakes, some ingenuity was needed to enable the engine to operate that valve using the same block-mounted camshaft arrangement used in two-valve engines.

The solution is a pair of rocker arms. One mounts on the rocker shaft where the exhaust rocker arm would be on a two-valve engine. Instead of acting on the valve, however, the first rocker pushes on a short, nearly horizontal pushrod that runs across the head to a freestanding stud-mounted rocker arm.

This second rocker arm pivots the movement into the right direction for the exhaust valve.

The three-valve heads are about 1 in (25 mm) wider than the two-valve heads, but they maintain the low profile that is an advantage of OHV engines. The new heads will work with the displacement-on-demand (DOD) cylinder-deactivation system that will arrive on the two-valve Generation IV engine and High Value V6 for even better fuel economy.

"The three-valve design adds complexity but uses the type of components with which GM is very familiar, so reliability shouldn't be a problem," said Frederick Rozario, Development Engineer, Advanced Powertrain at GM. "And while the added mass in the valvetrain might seem to be an obstacle to high

The valve covers on the three-valve heads protrude downward to envelop the relocated exhaust valves. The exhaust manifold features tuned, equal flow (though not equal length) runners for each cylinder.

rpm operation, the **Corvette** engine will rev to 7000 rpm with a 30% margin of safety. It can go to 8000 rpm safely," he added. A special jig will hold the parts together so the whole valve actuation assembly can be installed as a unit on the head.

"A weakness of single camshaft engines is the inability to separate intake-cam timing from exhaust-cam timing for maximum efficiency and minimal emissions. But a cam phaser that adjusts the advance or retard of even a single cam, depending on conditions, is still very valuable," Rozario said. "The cam phaser on this engine provides 80% of the benefit of a system with separate intake and exhaust phasers."

The phaser mounts under the water pump in the traditional timing chain location, so it does not require any additional space underhood. The water pump is new too, because the higher-output engine increases the demand for cooling. The 6.3-L version of the engine will produce 500 hp (373 kW), for example. So the new pump produces twice the 80 gal/min (300 L/min) of coolant provided by the two-valve engine's water pump.

The DOD system and cam phaser increase the demand for oil pressure, so both the V8 and V6 engines get improved oil pumps. The V8's is a two-phase oil pump, switching between high and low flow as needed to maintain the necessary oil pressure without suffering excessive parasitic losses when lower pressure is sufficient. The V6 is even more efficient, with a variable displacement oil pump that continuously adjusts its output for maximum efficiency.

The engines also feature optimized exhaust manifolds with equal flow runners for each cylinder.

Dan Carney

Virtual development helps Jaguar Racing

In the run-up to the British Grand Prix, the **Jaguar** Formula One team unveiled how virtual-reality mannequins of their drivers Mark Webber and Antonio Pizzonia are helping shape the cars of next season—the first time technology of this nature has been used to shape Formula One cars as opposed to road cars.

Jaguar Racing has taken on board a human modeling and simulation software solution currently being used by Jaguar Cars. The advanced simulation system from **EDS**, called Jack, takes an exact reading of each driver's body, from overall height to the length of the arms, from the width of the legs to the reach of the fingertips. The virtual-reality Formula One drivers can then be sat inside a digital cockpit while the car is still in the preliminary design stage.

Jaguar Racing has started using the human modeling and simulation software Jack, from EDS, currently used by Jaguar Cars.

Jaguar designers can then evaluate whether the seat, steering wheel, arm rest, and gear shifters are in the best location for each driver. The interior can be improved so that Webber and Pizzonia have the best possible positioning and posture to operate the race car—the gear change is just a touch, the steering wheel positioning is perfect, and the accelerator is an extension of the foot. Blind spots will be reduced by determining what they can and cannot see. Such assessments will improve driver performance, reduce fatigue, and give the driver an edge in a sport where a 1/10th second is an advantage.

A virtual driver is created from exact measurements so Jaguar Racing can develop a digital cockpit design.

The occupant packaging toolkit add-on provides an accurate assessment of Webber and Pizzonia's driver's viewpoint,

so they can easily discover what the tires, body panels, and mirrors are obstructing.

Jack is also being used in the design of the engine, so the all-important access and reach by the mechanics in the pit stop can be evaluated first in a digital environment, enabling the fastest repairs possible. New mechanics can be trained on Jack simulations, giving them a good understanding of the car before they tackle working with the real thing.

Jack will also enable Jaguar Racing to make early checks on the design of the whole car in virtual reality, saving a considerable amount of money on costly mock-ups or prototypes.

David Alexander

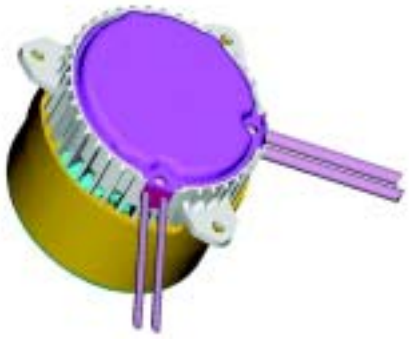
Cooling fan from Johnson Electric improves efficiency

As vehicles become more complex and engine compartments more crowded, one pressing challenge is to package more cooling capability into smaller and lighter assemblies. The latest addition to **Johnson Electric**'s Johnson Gate family of radiator cooling fan modules is now in advanced development. The modules provide automakers the opportunity to write algorithms to control engine, radiator, and cabin temperatures with a high degree of accuracy. Temperature is a function of fan-motor speed, and requirements vary with vehicle demands.

The Johnson Electric motor and its control circuit are securely nested into cavities provided in the fan shroud. Air passing around the pocket in the shroud will help keep the electronics cool. The supply cable can be securely anchored to the shroud.

Johnson Electric's modules employ a system in which the actual speed of the motor is fed back to the control module and small adjustments made to compensate and maintain the desired motor speed. In more sophisticated systems, sensors can be located at points in the vehicle for direct thermal feedback when temperatures need to be controlled precisely. The motor speed can be incrementally adjusted to maintain those temperatures.

The Johnson Electric modules package the fan motor and control electronics inside a shell to protect the system from harsh underhood conditions. The modules have also been designed to minimize electrical noise that might disturb other electronic components, and are hardened so that there is no deterioration if subjected to electrical noise spikes from other sources.



Johnson Electric has an optional design that integrates the control module with the motor. The control module becomes an axial extension of the motor, and is effective under conditions where there is no geometrical limitation on the overall length.

Advanced control methods will probably be used first in high-end vehicles where the price/performance is justified. However, Johnson Electric is developing lower cost solutions for all vehicles.

David Alexander

Eaton helps Lotus with camless technology

Lotus Engineering has signed a licensing agreement with **Eaton** Automotive to develop for production Lotus' Active Valve Train (AVT) technology.

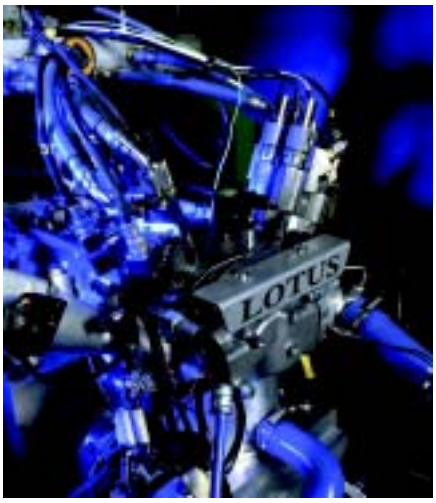
The companies will collaborate closely in the development of Lotus' current AVT research to meet the cost, packaging, and performance requirements of a production system.

The technology promises to reduce engine-out emissions and improve fuel economy, crucial to the global automotive industry as it faces increasingly stringent legislative standards toward the end of the decade. Furthermore, simulations show that for a conventional baseline engine, the improved operational efficiency increases torque by up to 10%.

Lotus and Eaton hope to have vehicles demonstrating AVT within two years and to have systems in production and available for delivery by 2008. An undisclosed "major" European vehicle manufacturer has already signed an agreement to acquire the AVT system for one of its platforms.

"Eaton's Automotive segment produces products focused on fuel economy, the environment, and targeted safety systems. Our collaboration with Lotus means we can get to market quickly with one of the most exciting developments in valvetrain technology for many years," said Stephen Buente, Eaton Senior Vice President and Group Executive—Automotive. "Between Lotus and Eaton there is the right mix of experience and know-how to make the AVT system a world-leading technology that is attractive to vehicle producers the world over."

The Lotus Active Valve Train system replaces the engine camshaft with electro-hydraulic valve actuation technology.



The fully variable AVT technology has a control system that achieves optimum efficiency across the entire load and speed range of the engine.

According to Lotus, the fully variable AVT system is several generations ahead of the various mechanical systems introduced by OEMs to improve the flexibility of their engines. It offers a level of valve control never seen before in production engines. Replacing the camshaft with lighter and more compact hardware, the electro-hydraulic valve-actuation technology enables virtually infinite manipulation of the timing, duration, and extent of lift for each valve. The control system selects and implements the valve lift profile that achieves optimal operational efficiency across the engine's entire speed and load range. In addition to reduced emissions and fuel consumption, Lotus' AVT technology offers increased torque and power output potential from the engine.

Furthermore, the AVT system will subsequently be an essential enabler for new combustion processes. For example, Lotus has demonstrated that controlled auto-ignition and homogenous-charge compression-ignition are capable of reducing engine-out nitrogen oxides emissions by up to 98%.

David Alexander

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