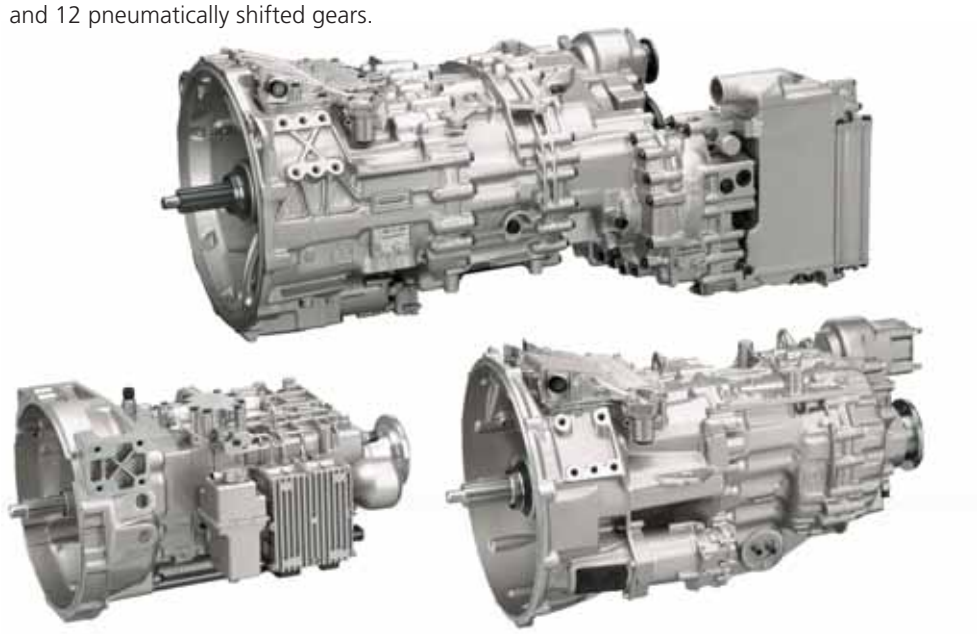
Getting there with ZF

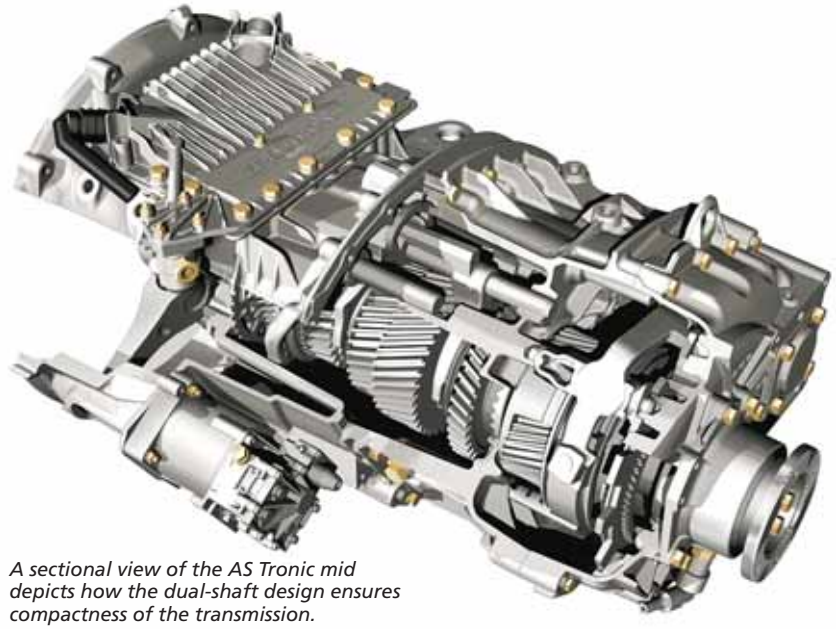
ZF is all over the place, which is not such a bad thing for a company that supplies not just to the automotive industry, but to the off-highway and aerospace industries as well. On the lighter side of the on-highway market, ZF is in just about everything from **Audi** to **Volkswagen** with its recognized transmission and axle products, but it also has a presence with products that may not be traditionally associated with the nearly 90-year-old company, including torque converters, steering systems, shocks, damping systems, tie rods, and flywheels.

Because of a business plan that includes both expansions and acquisitions, the Germany-based company has moved far beyond just Europe with a manufacturing presence in six out of the seven continents, with no supplier or OEM currently manufacturing in Antarctica as this issue went to press. A very short list of ZF products and technologies include the six-speed automatic transmission for the new **Land Rover** LR3, produced in Saarbrucken, Germany; axle systems for **BMW** 3 and 5 Series vehicles in China; 3 Series' axle systems in South Africa; and the front- and rear-axle systems for the **Mercedes-Benz** M-Class, for which the **ZF Lemförder** plant in Tuscaloosa, AL, is a dedicated supplier. The latter plant produces 11 different variants for the front and five for the rear axle of the M-Class, which will grow to more than 60 front variations and 20 for the rear for the next generation M-Class, surely a sign that the company's expenditure of €110 million in FY2003 just on car axle systems and components is being put to good use.

Just as ZF does not limit itself to one industry or one continent, it also does not limit itself to just light-duty on-highway applications. At this year's IAA Commercial Vehicles show, the company introduced automatic commercial vehicle (CV) transmissions for a variety of CV categories, including vans, light- and heavy-duty trucks, and in special vehicles, such as mobile cranes, that will go into production in 2005. For medium torque levels covering 800 to 1600 N•m (590 to 1180 lb•ft), ZF engineers developed AS Tronic mid variants of various lengths between 840 and 900 mm (33 and 35 in). The AS Tronic mid is based on heavy-duty technology, including a nonsynchronized three-speed basic transmission with synchronized range-change and splitter unit and 12 pneumatically shifted gears.



ZF will begin production in 2005 on the AS Tronic mid (right) and AS Tronic lite (left) transmissions to supplement the application potential of the AS Tronic (top). (Images courtesy of ZF.)



A sectional view of the AS Tronic mid depicts how the dual-shaft design ensures compactness of the transmission.

Briefs

A steering wheel with fixed central controls is a feature of the new **Citroën** C4, allowing optimization of the airbag and grouping of the main driving controls for easy access. The new functionality was made possible by a multiplexed connection designed and manufactured by **Valeo**. The standard top-column module and the controls set in the fixed panel of the steering wheel are linked by a LIN-CAN multiplexed connection, which was proposed by Valeo in the early stages of design in liaison with the steering wheel manufacturer and the supplier of the steering column.

The next-generation **Ford** Focus, recently launched in Europe, offers an advanced front lighting system developed by **Visteon**. The halogen headlamps are designed to adjust light distribution according to vehicle speed and direction, using inputs from steering wheel and speed sensors to tailor the light pattern. Asymmetrical movement of the headlights provides maximum forward illumination for the driver as well as projecting light into the corners. The control module also takes care of headlamp leveling.

The **Peugeot** 1007, a compact four/five-seat city car, will feature two motorized power sliding doors by **Delphi**. The large opening makes access to front and rear seats easier than a traditional hinged door, especially when parked in a confined space. Each door has a dedicated cable drive unit mounted under the rear floor for packaging reasons. The shared electronic control unit is mounted under one of the front seats.

The all-new 2005 **Ford** Mustang will feature brake systems from **Kelsey-Hayes**, a subsidiary of **TRW Automotive**. Working closely with their counterparts at Ford, TRW engineers helped to design and develop the complete system, including four-wheel disc brake calipers and rotors, booster and master cylinder, and ABS with integrated traction control. The actuation was carefully tuned to deliver brake pedal feel that is sporty and confident. The company will also supply ball joints for the Mustang suspension.

Unlike the larger AS Tronic, which has two countershafts, the midrange variant has one. This design change is claimed to contribute to improved torque capacity, packaging, and noise emissions. ZF engineers used several techniques to increase efficiency, including the change from immersion to injection lubrication. The gears no longer have to turn in the oil bath, eliminating churning loss.

The familiar shifting strategy and quality of the original AS Tronic is also provided by the AS Tronic mid, since it is using the same automation technology and control software as the AS Tronic, of which several hundred thousand units have been sold. Identical interfaces allow for easy installation and operation for manufacturers and operators acclimated to the older transmission.

For light-duty CVs, ZF engineers leveraged the 6 S 850 manual transmission as the basis of an automatic transmission to design the AS Tronic lite, the basic version of which is identical to the manually shifted version. The lite transmission features standardized hydraulic control technology that allows cost-effective production of the transmission, according to the company. Unlike the bigger AS Tronic variants, the lite uses an electrohydraulic control module. Power-dense hydraulic control units are more compact than pneumatic units and therefore easier to integrate.

The lite transmission does not depend on the compressed-air supply in the vehicle, which is important for the vehicle manufacturer, since integration of the transmission does not require the pneumatic system of the vehicle to be changed. This feature also allows use of the transmission in vehicles without compressed-air supply. The mechatronic module is integrated into the transmission and the system is delivered to the vehicle manufacturer as a complete unit.

Jean L. Broge

A powerful conversion

An innovator in the electronic materials and manufacturing industry has added another custom designed and developed dc/dc converter to its hybrid-electric vehicle contribution list via the **Ford** Escape Hybrid sport utility vehicle.

Since the 1970s, **TDK** has been manufacturing commercial power converters. Beginning in the early 1990s, the company began developing dc/dc converters and chargers for electric vehicles and dc/dc converters for hybrid-electric vehicles, like the **Honda** Insight and Civic as well as the **Toyota** Prius.

The dc/dc converter is a vital component in the overall operation of the new Ford Escape Hybrid. "Conventional vehicles are driven by the engine and they operate on the dc (direct current) power generated by the alternator. However, the hybrid-electric vehicle has a binary power source—a gasoline engine and electric motor," said Tomoshi Kondo, Engineering Manager, Power Systems Division for TDK R&D Corp.

"When the vehicle is stopped or under idling condition, the gasoline engine is stopped. When the gasoline engine is

The Ford Escape Hybrid uses a custom-designed dc/dc converter from TDK.

The dc/dc converter from TDK has several patents and pending patents.

stopped, the alternator does not generate dc power continuously," explained Kondo. To provide continuous power, a dc/dc converter performs the task, even when the gasoline-fueled engine is stopped.

The major components in the custom-made TDK converter include the power MOS (metal-oxide semiconductor) FETs (field-effect transistors), semiconductors, power transformer, power inductors, large capacitors, and connectors. "Many of the components used in the converter are designed and manufactured by TDK," said Rick Anderson, Global Account Manager for Ford at TDK Corp. of America.

On the Ford Escape Hybrid, the dc/dc converter provides a power source for numerous in-vehicle products. "The dc/dc converter takes high voltage stored in the battery pack—around 300 volts—and converts it into a usable 12-14 volts. This allows various vehicle systems to work efficiently," said Kondo. Since standard gasoline-fueled vehicles use a 14-V system, the vehicle's electronics—such as radio, headlights, gauge clusters, powertrain control modules—are designed for this input voltage.

The Ford Escape Hybrid's dc/dc converter underwent an array of tests for reliability (including high/low temperature, high temperature and humidity, thermal cycle, vibration and shock, water ingress) and noise (including electromagnetic compatibility and electromagnetic immunity). "There were several design trade-offs to consider on the dc/dc converter. The most challenging issue [was] designing a small, highly efficient converter that can withstand the automotive under-hood environment," said Kondo, adding that the dc/dc converter is mounted under the hood on a bracket in front of the passenger side strut tower.

TDK's engineering work with magnetics, capacitors, control circuits, and other technologies helped to move the dc/dc converter project to production application. "This experience has helped TDK work closely with Ford over several design iterations to produce custom power supply products to match Ford's hybrid and fuel-cell system requirements," said Anderson.

Kami Buchholz

TRW steers toward the future

Technicians adjust a new EPHS pump for commercial vehicles. TRW claims the compact pump is the only one of its kind that prevents leakage in high-temperature applications. (Images courtesy of TRW Automotive.)

TRW Automotive's next-generation electrically powered hydraulic steering (EPHS) system has been chosen by two "major European vehicle manufacturers of larger vehicles." It is scheduled to start production in 2006.

EPHS is one part of TRW's electrically assisted steering (EAS) systems that eliminate the connection between a vehicle's steering system and the engine. The company describes the EPHS system as consisting of a conventional rack-and-pinion power gear and a "very compact" motor pump assembly, which combines an electronically commutated brushless motor, a gear-wheel pump with a resonator, a tank for the hydraulic fluid, and an electronic control unit with the control electronics and the power electronics in one housing.

The EPHS system is available in two versions, one of which consists of a two-speed pump with switching logic, which switches between a stand-by mode and a demanded operating speed depending on the need of assist. The other version is a continuously variable system that uses an additional steering-angle sensor and matches the flow speed to the hand wheel operation and to the demand for steering assist.

TRW estimates that one out of every three cars built by 2010 will have some form of electrically powered steering (EPS), which gives credence to its other estimation that more than 200 models will be fitted with its steering systems through 2008, ranging from EPS through EPHS and hydraulic steering to manual steering systems. EPHS technology is expected to deliver improved fuel economy and lower CO_2 emissions, often associated with EPS systems, while delivering the required power, steering feel, and packaging options associated with hydraulic systems, which some vehicle manufacturers prefer.

EPHS systems are delivered as fully tested, ready-to-install units for what TRW describes as a cost-effective fuel-saving solution that requires a minimum of redesign to the vehicle platform.

Engineering Director of EPHS Steering Systems for TRW Automotive, Dieter

Fehlings, said, "In tests, the new generation of EPHS system delivers an 80% improvement in fuel economy compared to standard hydraulic steering systems. This reduction in fuel consumption leads to a respective 3% improvement in CO_2 emissions. The EPHS system also delivers multispeed, positive and responsive steering feel, and the possibility for vehicle manufacturers to fine-tune the steering characteristics."

TRW will also continue to develop its EPS systems—both column and rack drive systems—to "meet the needs of those customers who are choosing to move straight to this technology for its fuel efficiency and packaging benefits," said Alistair McQueen, Engineering Director for EPS Steering Systems. "EPS systems offer added functionality such as torque assist and integration with other chassis systems such as braking."

Column drive EPS systems are currently in production on **Renault**, **Nissan**, and **Fiat** models. According to Ken Lowe, Product Manager, Steering, TRW is in discussions with a number of customers regarding its rack drive technology, which will deliver EPS for D segment vehicles. The company is also developing enhanced power output for its column drive EPS system for upper C segment models. Like other TRW EAS products, the EPHS system has primarily been used in the past in smaller vehicle segments.

Jean L. Broge

Honeywell goes in the 1 Series

The new **BMW** 120d will have plenty of power, due in part to the use of a third-generation VNT (variable nozzle turbine) turbocharger from **Honeywell**. Since 1995, **Garrett**, a business unit of Honeywell, has offered to the passenger-vehicle market VNT turbochargers, which are an outcome of Garrett's research in variable geometry turbochargers.

At low engine speeds and small fuel flow, the VNT reduces the inlet cross section at the turbine wheel to optimize turbine power with the required load. At full engine speed/load and high fuel flow, the cross section of the VNT is increased, avoiding turbocharger overspeed and maintaining the boost pressure level required by the engine. According to Garrett, the cross-section modulation can be controlled directly by the compressor through the use of a pressure actuator, or by the engine-management system using a vacuum actuator.

The third-generation VNT turbochargers feature a new VNT cartridge that has been developed specifically to meet customers' needs for smaller, cleaner, and better performing engines. The new platform offers what Honeywell describes as several "high-performance innovations," including a new vane shape, a new-generation turbine wheel, and better

Garrett VNT (variable nozzle turbine) turbochargers, such as the third-generation version that Honeywell is supplying for the BMW 120d, adjust the gas throat section at the inlet of the turbine wheel to optimize turbine power with the required flow velocity.

The newest VNT attaches its variable geometry mechanism onto the bearing housing through an elastic shroud.

controllability, all combining to deliver 130% of second-generation VNT boost levels at just 90% of back pressure, according to the company. In the last 15 years, 13 million VNTs have been installed in vehicles, with the first application in 1989 being for a **Nissan** commercial diesel application.

According to Alexandre Ismail, Vice President and General Manager of the Europe Region for Honeywell Turbo Technologies, Honeywell is planning to make "a full range of the third-generation VNT turbochargers available for production launches for engines ranging from 1 to 3.5 liters."

Also fitted on the BMW 1 Series are Honeywell's JURID brake pads, which feature a Sandwich Metlock attachment that builds on Honeywell Friction Materials' extensive experience in using Metlock sinter bonding to attach the friction material to the steel backing plate of a disc brake pad. The new Sandwich Metlock enhances the overall strength of the pad assembly—particularly in high-temperature, heavy-duty applications—and adds to the safety reserves of critical components, according to the company. Honeywell's disc brake pads, drum brake linings, and a variety of application-specific aftermarket brake products are marketed under the Bendix brand name worldwide and the JURID brand name in Europe and Asia.

Jean L. Broge

Going from eight to four and back

A new technology allows select sport utility vehicles from **General Motors** to obtain fuel efficiency improvements up to 8% by reducing the number of cylinders engaged in the combustion process. **Eaton Automotive**'s Electro-Hydraulic Cylinder Deactivation System, marketed by General Motors as Displacement on Demand, is available on the 2005 **Chevrolet** TrailBlazer EXT, **GMC** Envoy XL, Envoy XUV, and Envoy XL Denali fitted with the Gen IV 5.3-L Vortec V8 engine.

The engine controller determines when it is appropriate to deactivate four of the V8 pushrod engine's cylinders. When the engine controller determines that vehicle speed or vehicle load requires additional engine power, the system reactivates full V8 performance.

The Chevrolet TrailBlazer EXT with the 5.3-L V8 engine is one of GM's vehicles equipped with cylinder deactivation technology from Eaton.

Eaton Automotive developed the deactivating roller follower (DRF) and a lifter oil manifold assembly (LOMA) with on/off solenoid technology, representing Displacement on Demand's primary elements. The deactivation/re-activation control algorithm and the design of the electronic controller are GM-protected intellectual property.

Interchangeable with a conventional roller follower, the DRF has the primary task of uncoupling the intake and exhaust valvetrain of four of the cylinders. The DRF consists of an inner and outer body connected together via two latches, a lost motion spring, a lash stop, and a conventional hydraulic lash element.

In an activated (coupled) mode, the latch spring keeps the latches engaged in an internal groove located in the outer body. The cam lobe acting on the roller bearing generates the full follower motion. Outer body motion transmits to the inner body via the latches. Inner body motion transmits to the pushrod through the socket. The engine valve is opened and closed similar to a conventional roller follower.

When in deactivated (uncoupled) mode, pressurized engine oil is LOMA-directed to an outer body groove, which causes the two latches to disengage. The pressure rise is timed to move the latches during the base circle dwell portion of the cam event. Motion is not transmitted to the inner body via the latches when the cam lobe lifts the outer body. The lost motion spring maintains force on the hydraulic element, and the engine valve is not opened. Exhaust and intake valve uncoupling is controller-timed so that burned exhaust gas charge is left in the inactive cylinder.

The primary purpose of the LOMA is to direct the engine oil pressure to or from each DRF as engine cylinders deactivate and re-activate. Mounted in the engine valley between the cylinder heads and under the intake manifold, the LOMA consists of several key components: four hydraulic on/off solenoids, electrical connection system, manifold, sealing gasket, engine oil supply pressure port, eight deactivation control ports, 11 engine mounting fasteners, and a system oil filter.

During non-deactivated cylinder operation, the LOMA serves as an air purging device to remove the air from the eight deactivation control pressure passages leading to the DRFs. "Keeping air purged out of the oil filled control pressure passages ensures rapid and repeatable cylinder deactivation response times," said Jerry Blevins, Director of Technology at Eaton Automotive.

The DRF (deactivating roller follower) is a two-state hydro-mechanical device.

When deactivation occurs, the electronic controller sends an input voltage to the LOMA commanding cylinders 1, 7, 6, and 4 to turn them off in sequential order. An energized solenoid opens to allow the engine oil system pressure to pass through the LOMA into the control pressure passages, and that increased oil pressure enables the DRFs to uncouple the inner and outer bodies. Roller follower lost motion occurs and the exhaust and intake valves remain closed, signifying a cylinder deactivation state. "The sequence is repeated for the remaining hydraulic on/off solenoids causing the engine to operate in a four-cylinder mode until engine loading is sensed or driver power demand increases," said Blevins.

When re-activation occurs, the electronic controller removes the input voltage from the LOMA, commanding all cylinders to turn on. With the solenoid closed, the oil pressure inside the control pressure passages will decrease to a level enabling the DRFs to couple the inner and outer bodies. "The sequence is repeated for the remaining hydraulic on/off solenoids causing the engine to operate in eight-cylinder mode," said Blevins, adding that the deactivation/activation cycle can occur several times in a given mile without noticeable valvetrain noise or perceived change in engine cylinder operation due to precise event timing—within two crankshaft revolutions—and computer control of the engine electronic throttle.

Kami Buchholz

The lifter oil manifold assembly (LOMA) directs pressurized engine oil to the DRFs to deactivate and activate cylinders 1,7,6, and 4 as required by the engine controller.