

Shift in power to the gearbox

Cars are still not clean enough and probably never will be. And that is good news for the makers of transmission systems. The spotlight on reducing exhaust emissions, once shining firmly in the eyes of the engine builders, is now more likely to be focused on the activities of the gearbox manufacturers. By **Susan Stefanini**

Gerald Andrews, managing director of the specialist engineering consultancy Ricardo Driveline & Transmission Systems, says transmissions are currently a “very hot topic.” He argues that for many years the vehicle makers have focused on engines as a way to clean up the environment, ignoring the potential benefits of improving downstream systems.

But, as it gets harder to tweak more efficiency out of an engine, he says people are looking elsewhere on the car for the untapped potential. “And, hey presto, there is this thing behind the engine called the gearbox that, for decades, has been relatively untouched. Now we are seeing enormous interest in the new generation of transmissions.”

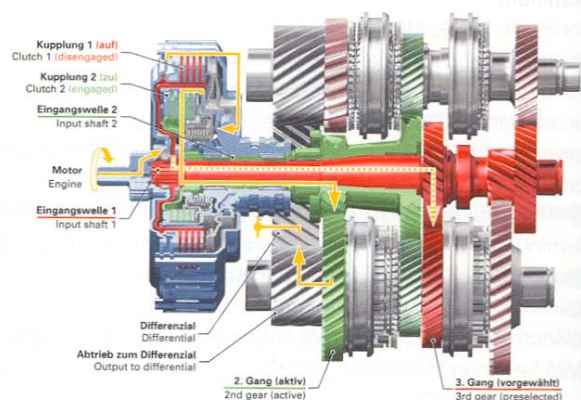
With powertrain systems accounting for some 30-40 percent of the value of a vehicle, it is clear that there is money to be made by those suppliers who tap successfully into the new transmission technologies. The ‘hottest’ area of interest, according to Andrews, is probably the dual-clutch gearbox, so named because it has two input clutches.

People who have driven pre-production models are both surprised and full of plaudits for the exceptionally sporty performance of this brand new smooth-driving automatic. It has manual override and additional steering-wheel-mounted paddles in place of a clutch pedal. Unlike any other gearbox including the other automatics or its nearest relative the automated manual transmission (AMT), this gearbox with its twin clutches – one for the odd-numbered gears and reverse; and the other for the even-numbered gears – allows the driver to shift smoothly up and down through the speed ratios without loss of torque or traction.

In this gearbox there is no torque converter to steal power from the drive. And while one clutch is active the next ratio on the second clutch is preselected, ready and waiting to be engaged.

Manufacturers’ advantages

Among the hype, there is some welcome news for the gearbox manufacturers. “The manufacturing advantage is that you can



Operating principle of the new DSG in the Audi TT 3.2 quattro

use the infrastructure that exists around the manual transmission. Manual transmissions are essentially cheap to produce and very efficient compared to a conventional automatic which is more complex,” comments Andrews.

Thus Europe, because of its pre-eminence in manual transmission systems, is where Andrews expects the dual-clutch technology to take off although he believes it will also generate much interest in North America and Japan, starting on niche vehicles. High output diesel engines fitted to trucks are also a ‘natural’ for the dual-clutch transmission, he suggests.

Meanwhile, GM Powertrain has already announced that it is working with the dual-clutch technology on a demonstrator truck because of its suitability for “high power, high rpm engines.” And, in what would be a direct challenge to the CVT continuously variable transmission makers, GMP believes the technology is “well suited to the integration of electric motors for hybrid applications” such as those being pursued vigorously by Honda with its Civic hybrid car.

The powertrain supremo has also noted that dual-clutch technology means more hardware which, depending on your viewpoint, could be good or bad news. But, in a message of reassurance directed to readers of *Automotive Manufacturing Solutions*, Andrews says he has seen no evidence of “wild and

wacky" manufacturing processes. "So people aren't coming out with plastic gears or nylon casings. We are not seeing a lot of revolutionary development in the way transmissions are made at the moment," he observes.

Fuel economy

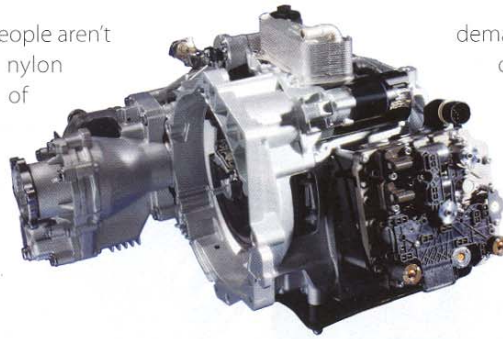
A key attraction for the dual-clutch gearbox is the excellent fuel economy with its beneficial impact on reduced emissions, especially CO₂. Depending on the car and its engine, fuel savings of up to 25 percent are possible compared with a conventional automatic gearbox according to an enthusiastic spokesman from Audi, who adds: "Drive handling? I loved it and I am not normally an automatic lover."

Andrews says shift quality is better than on his Mercedes. Calling the dual-clutch gearbox, "Ideal for a sports car and an absolute joy to drive," he explains: "The trouble with a conventional automatic is the torque converter which doesn't have quite the same sense of direct connectivity with the engine and transmission. With a dual-clutch, because there is no torque converter, there is more feedback. And you can switch modes from fully automatic to semi-automatic mode when it becomes more like a Formula One car."

The racing analogy is unsurprising given that the earliest use of the dual-clutch technology said to be some 20 years' ago in an Audi car competing in the 24-hour Le Mans. Lately Prodrive, the leading motorsports consultancy, has also been working on twin-clutch systems for competition cars. Similarly, Ricardo has engineered the drivetrain that has a 7-speed dual-clutch transmission with a shift speed of 0.02 seconds or less, fitted to the latest Bugatti Veyron super car and counts the VM as one of a number of high-profile customers for the dual-clutch technology.

Audi is first

Meanwhile this summer, back in the everyday world, Audi became the first VM to introduce the double-clutch technology on a volume production car. In August, in a break with tradition, the carmaker first launched a right-handed version of the Audi TT 3.2 quattro coupé with 6-speed gearbox into the UK where



Volkswagen DSG – sectioned model of gearbox unit

demand for small high-performance sports cars is deemed to be very high. In just three days dealer Audi UK took pre-launch orders for 1,000 cars, each selling for around £29,000 (\$47,000). The car has all-wheel drive, a tagged top speed of 250kph and accelerates from 0-100kph in 6.4 seconds. Shift speed is an exceptionally responsive 0.03 to 0.04 seconds.

By mid-September the dual-clutch gearbox, named by Volkswagen the DSG direct-shift gearbox, will be selling on the Audi TT coupé and Roadster versions in the UK and in North America while in Europe it will also be fitted to the sporty Golf R32. Others will follow over a two- to three-year period. In typically pioneering style, Volkswagen has bitten the bullet ahead of the pack and will roll out the dual-clutch gearbox on all of its mainstream models. According to a spokesman, this will include the Touran MPV as well as the smaller Passat and the Polo.

Volkswagen has filed more than 60 patent applications for the DSG which is being built at the company's gearbox factory in Kassel where it has invested €150 million (\$172 million) in production facilities capable of outputting 1,000 units per day. The transversely installed DSG gearbox was developed in a copy-book transatlantic partnership between Volkswagen and BorgWarner, a triumph of assiduous cooperation between the VM and its Tier I supplier over a period of five years.

DualTronic

Under the DualTronic brand name, BorgWarner (BW) developed the critical sub-assemblies that define the guts of the DSG, notably the dual-clutch module itself as well as the system's electro-hydraulic control unit. The dual-clutch module is currently being produced at BW's Heidelberg factory. As volumes ramp up, it will be built at a new facility at Arnstadt in the former East Germany. The E-HCU, on the other hand, will continue to be built at BW's plant in Tulle, France.

Combining BW's wet-clutch expertise with what it calls advanced control strategies, the DualTronic venture with Volkswagen is an important budgetary component of the \$1.2 billion investment scheduled by the group over the period 2003-2005. The company, whose VM customers include Ford, DaimlerChrysler, General Motors, Toyota, Honda, PSA, Renault-Nissan and Volkswagen as well as transmission maker ZF, expects to sign up at least two more customers to its DualTronic technology during 2003.

Meanwhile, the dual-clutch gearbox has won another admiring driver. Steve Gifford, vice-president sales worldwide at BW's powertrain technical center in Chicago describes his experience as "fantastic". He adds, "With no torque converter, you get a very rapid and very direct linear acceleration right from the start."

Volkswagen's Tiptronic shift technology which combines conventional automatic gear 'D' and 'S' (sports) selection with flick-shift manual override, is the principal means by which the driver interfaces with the DSG. Two rocker or paddle controls

By mid-September, in Europe the dual-clutch gearbox will be fitted to the Golf R32



fixed behind the steering wheel provide additional manual shift possibilities: one shifts the gears up a ratio while the other shifts down a ratio.

With the Tiptronic in 'D' mode, the driver can use the rocker on the steering wheel as a temporary 10-15 second manual override, after which time the drive reverts to automatic. A Tiptronic flick-shift manual override was first introduced on a Porsche in 1989 and was later fitted to the first production car in 1994, on an Audi A8.

Gifford speaks, too, of the manufacturing benefits. He comments that the reason dual-clutch gearbox technology is so attractive to many European producers is because it uses the same basic manufacturing equipment that they use to make manual transmissions. "This is one of the real key features, that it uses layshaft transmission technology," he says.

Fuel economy and resultant cut in emissions are, of course, the other main attractions. But, here, Gifford is perhaps more cautious than our man from Audi. He says, depending on the engine, it could be as high as 15 percent, or higher in the case of diesel. Figures used by BorgWarner are typically in the 8-15 percent range when compared with a conventional automatic gearbox.

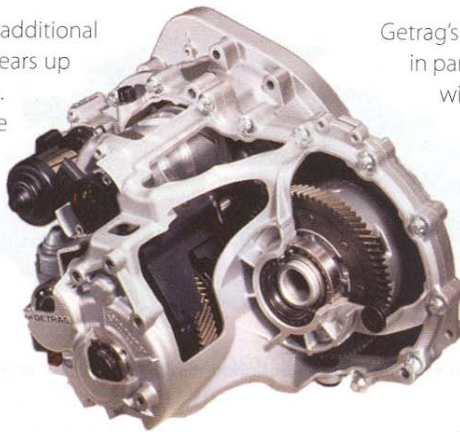
Conditional gains

When compared to a manual gearbox, the figures are more difficult to justify and any gains quoted for the dual-clutch technology depend on the fact that, while in theory, the manual gearbox is more fuel efficient, in practice most drivers are lazy and do not change gear when they should.

Dr Stephan Rinderknecht, VP engineering at gearbox manufacturer Getrag agrees. He says the drawback for the manual transmission is that the shift positions are fixed while shift change is determined by the behavior of the average driver. "Normally, the driver does not shift in a very economic way," he says.

Another hotly debated benefit of the dual-clutch gearbox is capital cost. Some observers liken production costs to a conventional automatic, and a spokesman from Volkswagen has said that its DSG unit actually costs around €500 (\$575) less to produce. As the company ramps up to become the world's only volume producer, it would be difficult to argue that point.

Rinderknecht, however, is more circumspect. One of the big challenges for the dual-clutch technology, he reckons, is to become cost effective in the marketplace. That depends on growing volumes comparable with conventional automatic gearboxes. "The problem is volume and not the production costs themselves."



Getrag ASG transverse transmission with electromechanical system

Getrag's interest in dual-clutch technology stems, in part, from a partnership agreement that it has with BorgWarner, not to mention its own longstanding tradition as a supplier of manual transmission systems. In common with other European producers, Getrag is not involved in producing automatic transmissions and regards that territory as a natural hunting ground. "Our interest and our effort is to bring the dual-clutch transmission to market as an alternative to the classical automatics," says Rinderknecht. "Volkswagen is the first to come to market; a lot more will follow."

European inroads

He notes that the European market for manual transmissions is around 85 percent of the total but that this will drop significantly over the next 10 years. Here, a preference for small sporty cars and a preoccupation with high fuel costs and emissions regulations will give the dual-clutch technology an advantage over bigger, heavier and more complex automatic gearboxes. In North America, he sees dual-clutch technology as the only alternative to the conventional automatic which has a 90 percent foothold. "You can only attack that market with a dual-clutch transmission as an alternative to automatic," he says, noting that success will depend partly on US emissions regulations tied in to fuel prices.

From a manufacturing standpoint, Rinderknecht identifies two areas of expertise that Getrag will need to acquire when it starts to build dual-clutch gearboxes which, at a guess, will involve BorgWarner's DualTronic components. One is additional assembly knowledge and the other is a clean-room facility. Both are needed to cope with what Rinderknecht calls the "automization parts", the electro-mechanical actuators or hydraulic components that comprise the main control unit of the dual-clutch gearbox.



Getrag's AMT, already fitted to the BMW M3, will now be in a position to target the lower A/B segment claiming advantages of efficiency, weight and packaging

"The automization parts are a significant part of the transmission. There are also more hydraulic systems. You need clean-room provisions," he says. Quality control levels will remain the same, however, in line with normal manufacturing practice while the demands on precision machining also

remain the same, dictated by the highest precision levels associated with conventional gear machining.

Third-generation AMT

While the dual-clutch gearbox and its successful launch in volume production is a major challenge for Getrag, Rinderknecht says the other main challenge has been to develop the third generation of AMT automated manual gearboxes with "significantly improved shift behavior and shift comfort".

TRANSMISSION HIGHLIGHTS 2003

The year 2003 has proved to be a bumper one for the introduction of new transmission technologies:

Aisin

the world's biggest gearbox manufacturer demonstrated the globally competitive nature of the transmission business when, in Japan, it developed an automated manual transmission (AMT) for Toyota, fitted to the European Yaris launched earlier in the year

Antonov

is 'knocking hard on doors' to find a manufacturing partner for its novel gearbox technology (see main story)

BMW

is working to develop dual-clutch transmissions which it sees as having a promising future, though the company is undecided as to which models will benefit first. "We are going to introduce this technology as soon as it meets the high requirements of the BMW Group for reliability, economic life-time, dynamics and comfort, under all possible driving conditions," a spokesman says

BorgWarner

expects at least two more customers this year to follow in the footsteps of Volkswagen and Audi in adopting its DualTronic dual-clutch technology (see main story)

DaimlerChrysler

introduces the 7G-TRONIC gearbox as a 7-speed replacement on Mercedes car models presently fitted with 5-speed gearboxes. Said to improve fuel economy and boost acceleration, the gearbox is world first for a 7-speed automatic gearbox fitted as standard

Ford Motor Company

announces that 70 percent of transmissions will be 'all new' by 2008 but, as yet, there has been no mention of dual-clutch technology. The company is focussed on CVT based on the Ecotronic CVT developed by ZF said to provide fuel economy improvements of up to 8 percent

General Motors

introduces the ZF Easytronic CVT to its new Opel Corsa 1.2, the first of several GM cars to get the option

Getrag

in addition to R&D on dual-clutch gearboxes (see main story), the company is working on a third generation AMT automated manual gearbox which, it says, looks especially promising in the compact segment where 5- or 6-speed automatics are not established. Getrag already supplies AMTs to the BMW M3 and smart cars

Honda

is the market leader in hybrid gasoline-electric cars with the Civic Hybrid which won the International Engine of the Year Awards 2003 best fuel-economy class. Using a dual-clutch gearbox in place of the more usual CVT could improve fuel economy even further. Early last year, Honda signed a non-exclusive licensing agreement with Antonov, the first OEM to acquire the rights to the patents

NZWL

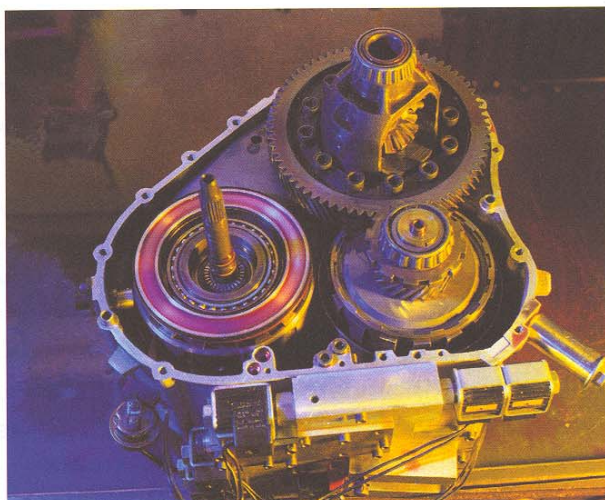
in 2001 signed a non-exclusive production license agreement with Antonov to use its patents to manufacture and sell its transmission developed for small cars. Back then, there were plans to commence production in 2003 or 2004. Could NZWL be the mystery gearbox manufacturer that Antonov hopes to bring on board as a manufacturing partner? (see main story)

Toyota

breaks into the AMT automated manual transmissions business with an AMT developed by gearbox manufacturer Aisin and installed on the European Yaris launched earlier

ZF

the ZF Ecotronic CVT transmission is selling well



The AAD Antonov Automatic Drive gearbox is light and designed for installation with transverse front-wheel-drive engines

But although the technologies are closely related, he sees them serving two distinctly separate markets. Getrag's AMT, already fitted to the BMW M3 and smart cars, will now be in a position to target the lower AB segment claiming advantages of efficiency, weight and packaging that make it particularly suited to small, front-wheel drive vehicles. In contrast, the dual-clutch gearbox targets C segment vehicles and above.

Like Getrag, Antonov, the Dutch patent holder of an automatic gearbox technology, hopes to compete in the small car market with a design that is small, light, low-cost and fuel-efficient. With a length of 250mm, the AAD Antonov Automatic Drive gearbox is also light, weighing around 55kg compared with the average of more than 80kg and is designed for installation with transverse front-wheel-drive engines.

Newly appointed CEO Martin Schinzig is optimistic that his mission to secure a manufacturing partner will succeed. "We are looking for a partner who will engage with us to do the next step which is mass production." While he will not name the companies involved, Schinzig says that he is talking to two gearbox manufacturers, one in Japan and the other in Germany. He is clear that that is the way forward, in line with the trend among VMs to source complete systems, including gearboxes, in order to manage the risk.

Against the competition, notably the AMT and dual-clutch gearboxes, Schinzig is confident that the AAD has a great future in the AB small car sector. "Weight is something absolutely crucial," he says, noting the trend for engines including diesels to become bigger while the AAD's compact length is also a major selling-point for many VMs.

From what he says, an announcement could be imminent. "With our German gearbox manufacturer we analyzed very deeply the manufacturing process and what we know today is that our gearbox is really feasible," observes Schinzig.

In the C segment and above, Ricardo's Andrews remains optimistic that the dual-clutch gearbox will displace both manual and conventional automatic gearboxes in terms of market share. So, is this the transmission of the future, perhaps? He concludes: "We believe so. And judging by the enormous amount of interest from our customers, they see likewise." ■