IHS **Automotive**

Sectoral Report

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The Automotive Transmissions Report

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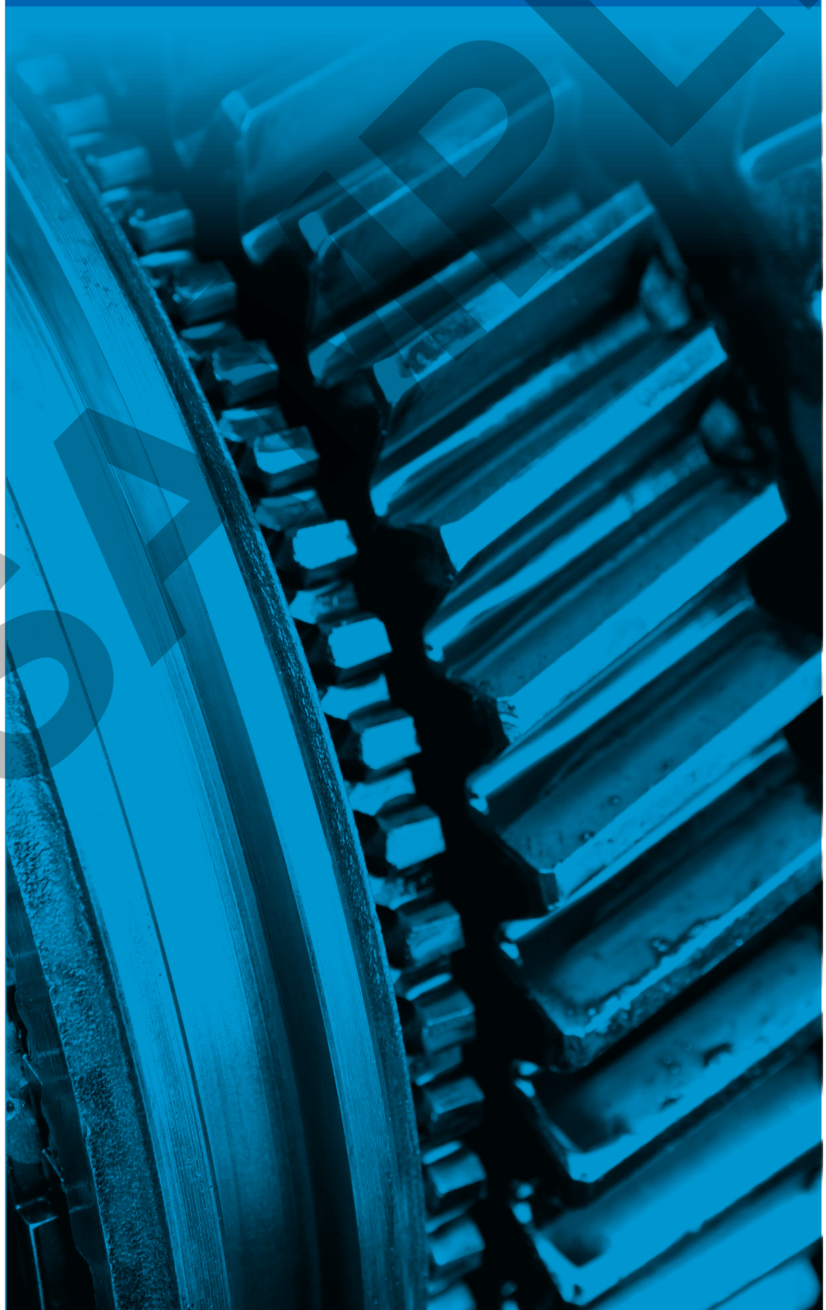

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The General Motors Easytronic system was developed in collaboration with LuK and, in an attempt to improve shift quality the clutch release travel was set so that the clutch was engaged only sufficiently to transmit the amount of torque being delivered at the time in order to reduce the interruption time. Mitsubishi, on the other hand, used a drum-operated shifting system on the Allshift similar to that used in motorcycle transmissions, so that the synchromesh of the next gear is engaged as that of the other gear is being disengaged.

The optimisation of shift strategies can increasingly make up for the torque interrupt shortfalls of the AMT and reduce this to a minimum through intelligent gear change actuation. Sensors, as illustrated in Error! Reference source not found., can be used to relay a complex matrix of information to the control system, and using relevant algorithms the system calculates optimum shift points and controls the clutch and shift points automatically. Today this technology can also be used to enhance safety by briefly interrupting torque in order to counter the risk of skidding.

However, despite the technological progress made and the potential for both fuel and cost efficiency, AMTs have continued to suffer from poor or inconsistent shift quality under all driving conditions compared with ATs and DCTs. While there have been several technological attempts to rectify this, some of which have been mentioned above, the single-clutch AMT has never really been accepted by consumers apart from in low-cost A and B segment cars in which shift quality has been less of an issue.

There has been a wide range of exercises designed to benchmark AMTs against both MTs and DCTs because, despite shortcomings the overall concept is highly attractive:

Theoretically AMTs have advantages over MTs, DCTs and ATs:

- Optimising shift strategies minimises fuel consumption more successfully than MTs;
- Similarly the optimisation of shift management can minimise emissions compared to MTs;
- AMTs are favourably priced in comparison to both ATs and DCTs, and in fact can be very competitive against MTs where suitable modularisation and scale economies can be used together with existing installed capacity for MTs;
- AMTs generally enjoy packaging advantages over ATs and DCTs;
- On-vehicle weight is usually round 20% lower for AMTs over DCTs, which usually amounts to some 40Kg;
- The AMT can be around 4% more fuel-efficient than a wet clutch DCT.

This means that there is considerable motivation for AMTs to be developed that can boast a higher shift quality, the single real impediment to their widespread use.

To this end electrification has begun to provide the solution, using an electric machine to infill torque during the gearshift. In addition, this development solution lends itself well to progressive hybridisation solutions.

Oerlikon Graziano and Vocis Driveline Controls, its part owned UK partner, have developed an innovative 7-speed automated manual transmission (AMT) that combines the dual-clutch principle of a DCT with the lightweight and compactness that is possible with an AMT when no manual option is required.

Designed for application in the new Lamborghini Aventador, the 79kg gearbox is substantially lighter than its predecessor yet provides an extra ratio, handles more torque and maximises cabin space by packaging into an exceptionally narrow transmission tunnel.

The new, 6.5 litre Lamborghini engine delivers 700 bhp (515 kW) at 8,250 rpm and 509 lb ft (690 Nm) at 5,500 rpm, which would normally require a substantial transmission. A conventional AMT, with external control systems, would not fit the available space; neither would a DCT, which would require bulky wet clutches to meet the power handling requirements.

An AMT uses the established "H" pattern gearshift of a manual gearbox, in which the various gears are selected by sliding

Dual clutch automated manual transmissions (DCT)

The DCT is now making serious inroads into the transmissions market, particularly in Europe and IHS forecasts that they will make up around 8% of global production by 2017 or 7.5 million units, up from 5% in 2013 (4 million units).

The underlying advantages of DCT as a transmission technology have proved compelling in recent years, particularly as wet-clutch DCTs have proved to have shift quality as good as that of a planetary AT. They are also as easy to drive while providing a more responsive drive for sporting applications. DCTs are more economical than a six-speed MT and hence can make a useful contribution to CO_2 reduction across the full range of vehicle segments, with feature content adjustable through electronic control mechanisms, particularly the capacity to ensure that the engine is kept within its most efficient operating range.

Historically the DCT was developed to deal with the torque interruption and shift quality issues associated with automating manual transmissions with a single clutch set. This was achieved using two clutches configured so that one is always engaged. However, due to the design challenges encountered when developing DCTs, the underlying relationship between MT and DCT design and production was quickly diluted and negated as an underlying development driver.

DCTs can be considered as two AMTs in parallel (one with first, third, fifth, seventh where fitted and reverse gears, the other with second, fourth and sixth gears) with the next gear pre-selected and ready to be engaged in the inactive part of the gearbox before the torque is moved from one clutch to the other without torque interruption. The electronic control system can also be used to fill the 'torque hole' during the shift by increasing engine torque output momentarily, a feature that Ford promotes on its Getrag-developed 'PowerShift' DCT. The driver can only just feel this torque handover and the shift characteristic is similar to a traditional AT.

A DCT can be operated in fully automatic mode, typically with the options of 'drive' automatic or 'sport' automatic settings, or in 'manual' via a shift lever or steering wheel-mounted paddles that enable sequential shifting. In the 'drive' automatic mode, the engine is kept in its more fuel-efficient operating range while in 'sport' mode the shift points are at higher engine speeds. The technology is also easily suited to stop-start technology, since the transmission is typically designed to shift to neutral when the vehicle is stationary in order to be ready for launch in first gear and to minimise oil churning losses.

Both dry and multi-plate wet clutch systems have been employed, typically in a concentric arrangement, although BorgWarner's low-cost DT170 unit has two separate clutches mounted on the two separate gear shafts and linked by a chain.

DCT Suppliers

BorgWarner

BorgWarner, and is the leading global supplier of wet dual clutch and electro-hydraulic control modules. The company has been producing for the Volkswagen Group since 2003 (re-branded Direct Shift Gearbox (DSG) transmissions) and they are a major supplier of DCT components to a number of other European OEMs.

In 2009 the company established a joint-venture with the China Automobile Development United Investment Co. (CDUI), which is owned by 12 Chinese OEMs. This joint-venture is known as the BorgWarner United Transmission Systems Co., Ltd., and is located in Dalian, China. The company has produced various dual-clutch transmission modules beginning in 2011. The JV will manufacture and develop core modules for the DCT assembly including dual clutch modules, torsional vibration dampers and control modules.

