Supplier Business

The Automotive Transmissions Report

2013 Edition
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TRANSMISSION DEVELOPMENT CHALLENGES

Packaging

With the ever-present constraints on packaging, the choice of transmission type is fundamentally affected by whether the engine is mounted longitudinally or transversely across the engine bay. Typically, longitudinal engines, when not using an MT, are more easily migrated to an AT, although transmission tunnel intrusion into the passenger compartment is becoming less acceptable because of competition for cabin space from a growing range of interior systems such as climate control components and entertainment systems.

Transversely-mounted engines, which are found in more than three-quarters of all new light passenger vehicles, introduce constraints on transmission length if it is to be mounted on one end of the engine, which is the most common configuration. Some OEMs have overcome this by mounting the transmission behind the transverse engine, but this introduces a different set of packaging challenges. When an MT is specified, some OEMs have opted for a shorter, three-shaft configuration in place of a conventional two-shaft unit, but this tends to increase the transmission’s weight and production cost, and can reduce efficiency. Where an automatic or automated transmission is specified, DCT technology has considerable appeal, and although there are often increased cost and weight, and the added bulk of clutch and shift actuators, they tend to be relatively short and compact.

Figure 28: Average vehicle weights by sector [Source: IHS SupplierBusiness]

For many years AT development was hindered by the limitation that more than four ratios led to virtually insurmountable packaging problems because of the large increase in the transmission size. However, development by French engineer Pierre Lepelletier led to the use of three planetary gear sets to achieve six ratios with, according to ZF, a
13% reduction in weight and an up to 30% reduction in the number of components. Mercedes-Benz claims that the 7G-Tronic seven-speed AT is barely larger than the company’s current five-speed.

**Weight**

One of the key concerns that OEMs and designers face in transmission technology is weight reduction. The average mini segment vehicle increased to close to 1,200kg in and similarly the European lower medium segment increased to 1,350. As Figure 28 illustrates, vehicle weights are now coming down and vehicle lightweighting is beginning to deliver results despite the ongoing counterbalance of additional systems and safety equipment. It has been estimated that a 10% improvement in kerb weight can deliver fuel efficiency improvements of 5-8%, therefore, as a component of high relative density and weight the transmission is a candidate for weigh reduction, where possible. Current developments in this area centre on using magnesium for casings, although there is really nothing new in this approach as VW used magnesium for its transmission casing in the Beetle. However, it is likely that lighter materials will be used more in transmissions as opportunities present themselves in an effort to bring down overall vehicle weight.

Currently, in weight terms, all alternatives to MTs incur some penalty. AMTs require the addition of electro-hydraulic or electromechanical clutch and shift actuators as well as an electronic control unit, all of which add about 10% to the weight. DCTs, with similar features and the addition of another clutch module, are likely to add 25%. Five speed ATs are typically 40% heavier than an MT on an equivalent torque basis and Lepelletier-based six-speeds about 30% heavier than a five-speed MT.

Transmissions housings are almost all produced in aluminium today, although magnesium is an attractive alternative. In Europe, the increase in using magnesium as a structural lightweight material has been led by the Volkswagen Group of companies, with the material also being used by other leading manufacturers including Daimler (Mercedes Benz), BMW, Ford and Jaguar. Magnesium use in the current generation Volkswagen Passat, the Audi A4 and A6 is around 14kgs. All those vehicles use magnesium transmission casings cast in AZ91D alloy, offering a 20%-25% weight saving over aluminium.

The past decade has also seen the launch of many innovative plastic components including plastic oil sumps for transmission systems. The BMW 7 Series featured an automatic transmission system from ZF Getriebe that uses Bayer’s glass fibre-reinforced polyamide, Durethan®. It had previously not been thought possible to manufacture such components using plastic due to the extreme requirements for protection against stones, tightness of the flanges and structural rigidity. This development is therefore seen as a significant landmark and polyamide is now a competitive material to replace metal in some transmissions applications in the future.

**Torque density**

A strong trend that has influenced transmission development in recent years is the increasing torque density of the internal combustion engine – the amount of torque produced per litre of engine capacity – such that despite the current trend for engine...
downsizing and downspeeding, the torque output is increasing significantly. A significant factor in this has been the increasing refinement and popularity of diesel engines, which typically produce higher torque output than gasoline engines and therefore place higher torque handling demands on the transmission.

Perhaps the simplest way to respond to this is to use sturdier transmissions with larger clutches, gear sets and bearings, but this is likely to increase weight, size and cost – three attributes typically all constrained during vehicle design and development. Alternatively, the torque density of the transmission itself must also be increased so that a smaller unit can handle a higher level of torque load.

Of the several transmission technologies that are now popular, the one that has achieved the greatest progress in torque density during recent years is the CVT, which used to be limited to low-torque applications. Despite the appeal of compact packaging, only a few years ago CVTs were not considered a viable technology route for applications where the torque handling demand exceeded 250Nm (181lb.ft). However, Nissan now uses CVTs on its 3.5-litre V6 engines that develop maximum torque of more than 350Nm (253lb.ft).

**Ratio spread**

The quest for improved fuel economy and transmission performance, coupled with the trends of engine down-sizing and down-speeding, have led to the need to increase the ratio spread of the transmission. Lower initial gearing is necessary to enable a smaller ICE to launch the vehicle with adequate acceleration performance while taller high gearing is necessary to provide highway speed cruising with optimised fuel economy. In order to achieve this extension of ratio spread in both directions, more ratios are required to ensure that the engine is kept as close as possible to its most efficient operation speed and to provide high-quality launch and acceleration performance, with a high level of passenger comfort.

The trend towards more ratios is evident in all the stepped transmission technologies:

- The six-speed MT is overhauling the five-speed in terms of production volumes and four-speed units are confined to a small production volume for low-cost, small vehicles in developing regions. AMTs based on MTs have followed the same trend.
- The most common planetary ATs once had fewer than five ratios but the six-speed is now the dominant configuration globally while seven-, eight- and nine-speed units are now available in the market and are forecast to increase market share.
- Only a few years ago, the first DCT was a six-speed unit. Seven-speed DCTs are now commonplace within the DCT sector and nine-speed units are becoming available.