Inside job

While some premium car makers rely on suppliers for latest-generation products, Daimler has its core gearbox engineering and development capabilities in-house. And that's not going to change anytime soon, says **Dr Uwe Keller**, head of transmissions at Mercedes-Benz

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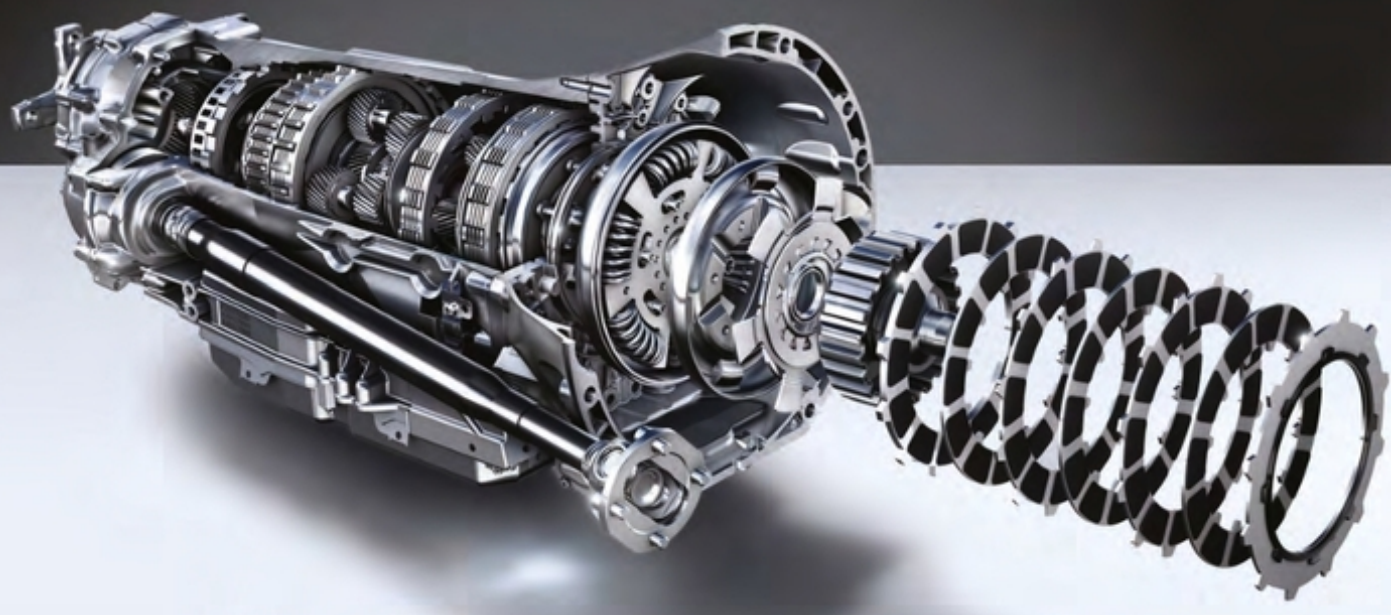


It wasn't so long ago that Daimler was saying five gears was the optimal number for a transmission. Then it was seven and now nine's the level to strive for. There aren't degrees of perfection, so just what's perfect now?

For particular points in time, they were all perfect. We launched the 5-speed in the 1990s, then the 7-speed in 2003 and the 9-speed in 2013. We talk a lot about speed and gears. With the 7-speed, we had a ratio spread of about seven; with the new transmission we have a ratio spread of nine. We can talk about gears, but they only come from the spread you require to get the best fuel consumption with the engine.

Why did you opt for a spread of nine?

We have to look at the best range of fuel consumption in combination with other factors, so that's why it's a ratio spread of nine for the new transmission. A spread of nine will not go with a 7- or a 6-speed design. When we want to increase efficiency, we have to increase the spread, and therefore the gears, and make them as smooth as possible, otherwise the revs are too high and too different and that's why we stay with a ratio spread of nine.

So, where does it end now that you're at 9 speeds and VW is up to 10 with its DSG?

When we put additional ratios in a planetary set we can go 7, 8, 10, whatever, really. The ratio spread is one thing, but then there is efficiency too. In this respect, we have to be careful not to use more clutches and brakes. That's why we came up with the design we did for this new transmission. We reduced friction losses and hydraulic pump losses and made a big step forward with the 9-speed design overall.

How big a step forward?

We save 6-7% over the 7-speed in terms of efficiency with this new transmission alone. Fuel tests like the NEDC bear that out, but so does the real world. So when you go into the real world you will see similar savings over the previous transmission with our new transmission. Naturally, it will be better in countries and markets where you have a large number of motorways or places where you can run at more than 80-90km/h [50-56mph]. So with our new transmission, you drive with a very low engine RPM due to its increased ratio spread. When you can cruise like that for a long time, you can make quite big savings in fuel consumption.

Is that 7% gain just against the transmission or for the car as a whole?

When you reduce friction losses, you reduce them for the whole system, not just for the transmission. So when you have higher torque, the losses are less important, but they are still there and present.

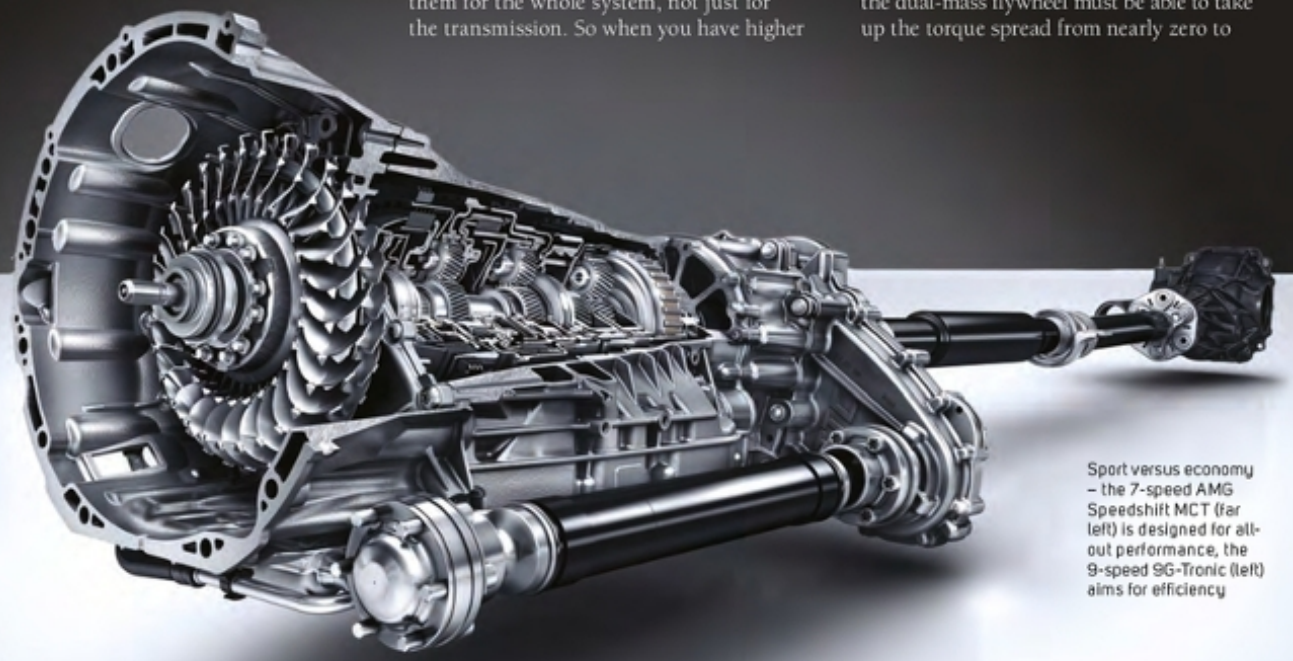
What were some of the key engineering areas and innovations to reduce friction and improve efficiency?

We did a lot of work on the torque converter and there is a dual-mass flywheel too. The design allows us to use much lower RPM, as mentioned already, but especially so with diesels, and that's through the dual-mass flywheel that we worked on with Schaeffler. We were the first to integrate that technology with an automatic transmission. One of our competitors will use that kind of system on a diesel soon, but we had that setup already with the 7-speed unit.

The ultimate aim is to have the best absorption of vibration levels and to avoid vibrations getting into the system. We also integrated a damping mass to get a better overall absorption. This entire development represents a big effort from us, and we managed with a diesel six to come down to 1,000rpm, so it can cruise from that speed with acceleration without shifting back. That's actually very difficult to do without gaining and passing big vibrations from the car to the driver and without also using a dual-flywheel damping system.

What technical challenges did you encounter during the project?

In some applications we have 700Nm so the dual-mass flywheel must be able to take up the torque spread from nearly zero to



Sport versus economy – the 7-speed AMG Speedshift MCT (far left) is designed for all-out performance, the 9-speed 9G-Tronic (left) aims for efficiency

700Nm. The RPM is one challenge and the torque aspect is another challenge.

In your opinion, what's the limit on gear numbers in vehicles?

On the truck side, we have 16 gears but only up to 80km/h (50mph), so it's a question of which ratio spread you want to install. For passenger cars, it's about the combination between engine and transmission, and we think nine is a good fit with our powertrains. Ultimately, we have to look for efficiency. If we have more gears we need more clutches, more brakes, more hydraulics and more shifts.

We recently drove with a guy who complained that he couldn't get the GLC's 9-speed to actually get into ninth gear on a motorway...

It will get into ninth gear on a normal cruise at 100km/h (62mph). Normally, the shift map looks at the driver's style to see whether he's being dynamic or not. Maybe it will stay in eighth or seventh gear to give a more immediate response if the driver has been driving that way, or is in Sport or even Sport Plus mode. The drive ratio is 3.46, so if you calculate it backward, it should be going into ninth quite easily at 90 or 100km/h [56 or 62mph].

Your engineering team is still developing automatic transmissions in-house. Are you considered a big player in this area?

When it comes to planetary automatic transmissions, there are three big suppliers for premium cars. There's ZF, which supplies BMW, Audi and Jaguar Land Rover; Aisin in Japan; and then there's us, with an annual production figure of around 1.5 million units.

So the automatic is going from strength to strength. How does the manual sit with you and your teams?

For rear-wheel drive applications, we have a very, very high take-up rate of automatic transmissions. In this respect, the manual transmission realizes only small production numbers with Mercedes-Benz.

What is the future for manual transmissions, not just within Daimler, but for the industry in general?

For the manual, there is not a big market in the premium sector anymore. We have it mostly with front-wheel-drive applications, but not much for rear-wheel-drive vehicles.

1. Daimler's focus on developing ATs in-house makes it a big player in the transmission industry

2. The new GLC is fitted with Daimler's 9-speed automatic, which has a wide ratio spread of 9.15:1

Worldwide, though, the manual is still the highest volume transmission. For example, in other countries, especially places like India, the manual is still very strong. Looking ahead, however, the dual-clutch transmission, which we have in front-wheel-drive vehicles, is derived from manual technology and I think it will take over in this area. I really do think that in the premium segment the era of manuals is definitely coming to a close.

During the project, which part took the most development work for the 9-speed transmission?

You have to take into account electronics when it comes to automatic transmissions with planetary sets and torque converters – that's very important. With the 9-speed, the electronics are fully integrated. We did not make an additional control system. For this development we made a direct control system for actuating the system, magnetic and direct-actuating a clutch or brake in the actual system. We made a lot of things fit in a heavily integrated system and that's why we could package two more gears.

Will hybrids make a big difference to the transmissions sector?

At the moment the industry is going for plug-in hybrids, where you take a base transmission and integrate the electronic machine within the automatic transmission

or a drive clutch. This technical arrangement has the same packaging size as other solutions, which is very good for engineers and the production line too. The next stage I see is that there will be an electric machine – not as an add-in, but as a vital part in the transmission subsystem. It won't be the case that we can choose an electronic version of that transmission or not. The electric motor will simply be planetary and completely integrated.

If it's so much better that way, why not do it now?
At the moment we have a smaller number of hybrid powertrains than IC engines, so it makes sense not to have a dedicated hybrid transmission. But in the near future, maybe a 5- or 10-year timeframe, a dedicated hybrid transmission will be needed. Right now we have a drive-off element and the electric motor. With the 7-speed we have the clutch and an electric motor. So the question is, do we need both? Do we actually need two elements? And why not organize one that manages all the jobs?

From an engineering perspective, are you heading that way already?
With the hybrid E-Class in 2012, we started with the transmission based on the 7-speed and we delivered that in the second- and third-generation transmission. With the bigger ratio spread we can realize better efficiency, which is an important thing for hybrids. The drivetrain and the transmission have a bigger impact on consumption in hybrids than they do in a normal IC engine. So regenerative braking is the key to hybrids, and that's the biggest part the transmission and drivetrain can play. When we can brake with the electric motor only, we have greater efficiency. That's why we are looking quite deeply within the entire drivetrain and at increasing that efficiency, especially for hybrid vehicles.

What are the challenges for you with other electrified transport modes, such as battery electrics and fuel cells?
Battery electric and fuel cells should have at least two gears. And for regeneration, there's no difference in that – the charge is the same. When you start looking at plug-in hybrids and battery electrics, the drivetrain becomes a far bigger focus. With a BEV application there will be an e-motor and inverter fully integrated in the car with a 2-speed transmission – and it has to have at least two speeds. So, this is all in one unit and the integration level will be much, much higher in the future.

But it has to have at least two gears?
How many gears it has depends on how high we want to go in RPM from the e-motor. For BEVs that need to tow something, for example, you will need more gears. Maybe it's not the most common thing you are asked for from electric vehicle buyers, but it could happen if they become widespread and when there is a higher take-up rate of electric vehicles.

What influence will autonomous driving have on the conventional powertrain and transmission?
Obviously the desired and required level of vehicle comfort will further increase. But as long as you react with your feet on the pedals, you'll still accept some feedback or reaction from the car, and that's especially in sporty modes, when you want it to act quickly and with some small shock to give you the response you're looking for.

For the transmission, while driving autonomously you might be sitting there with the laptop or having a conversation and there has to be a further increase in comfort because you don't want to feel any shifts in this type of vehicle – and there's no reason to feel any shifts anymore. So, the biggest challenge is getting away from making this sporty transmission and calibration, to a more comfortable setup for this type of application.

What's the biggest change you've seen in transmissions R&D over the last 20 years?
Twenty years ago, some people developed an engine while others developed a transmission – and then they found themselves together in a car. Nowadays we do it quite closely as one powertrain. We use a 'one system' development approach.

"We managed with a diesel six to come down to 1,000rpm, so it can cruise from that speed with acceleration without shifting back"

There's a far bigger focus on the drivetrain with PHEVs, says Keller