

# Torquing shop

Generally speaking, powertrain development is about incremental evolution of mature engineering technologies. Just sometimes, however, there are revolutions. Brian Tinham talks to the team at Torotrak



Above: Torotrak's Andrew de Freitas  
Bottom right: Steve Murray

So, IVTs (infinitely variable transmissions) are one step closer to becoming a reality for main drives in the heavy-duty commercial vehicle world. With Allison Transmission handing Torotrak £2.5 million as an advance pre-production licence payment for further development of its novel gearbox technology, it's almost unthinkable that this revolutionary powertrain component will not come to fruition in the not too distant future.

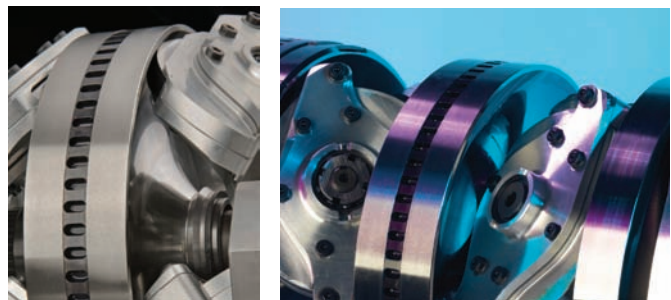
Make no mistake: Allison is at least as serious about this project as it is about its H 3000 hybrid transmission TC10 10-speed twin countershaft torque converter. And, for that matter, the firm's fifth generation electronic control module, launched at September's IAA commercial vehicle show in Hannover – with its built-in inclinometer, aimed at increasing vehicle productivity and efficiency in stop-start operations by improving the speed and accuracy of LBSS (load-based shift scheduling).

## Inside the toroidal variator

The toroidal variator comprises pairs of power input and output discs, mounted on a single shaft and in close contact with guided rollers sandwiched between them. The space between each disc pair forms a convex doughnut shape (the toroid), so the rollers vary the output disc speed and torque according to their angle of precession. Hence the effective gear ratio and power.

Making this work is a hydraulic control system that not only supports each roller, but also steers it across the disc face via a single connection point. Applied force determines output disc speed. The rest is about the geometry of the variator itself, the number of rollers (usually two or three per toroidal cavity, depending on power density and cost requirements) and materials of construction – generally bearing and gear steels.

The final key factor is the synthetic traction fluid, which transmits power between the discs and rollers by instantaneously becoming highly viscous under compression.

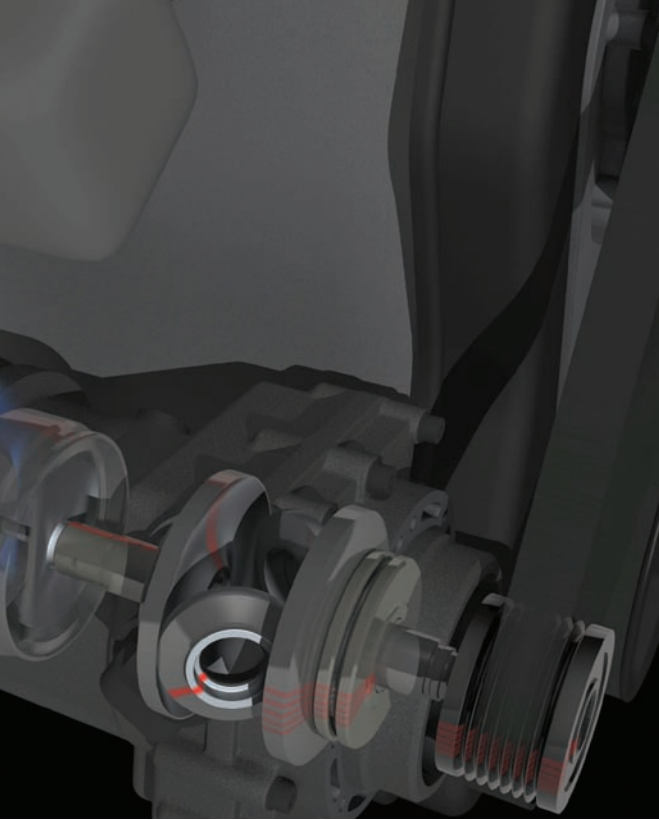


Indeed, IVTs are surely part of the gearbox giant's promise to bring advanced automatics back into the mainstream as full-on AMT (automated manual transmission) challengers. Bear in mind that Allison has now paid approaching £20 million over the last 44 months, and is also due to invest a further £8.1 million next year on the ongoing design and analysis programme currently being led from its headquarters in Indianapolis. Torotrak says it has already conducted more than 25,000 hours of testing specifically for Allison in the last 18 months alone.

## Big names in the frame

"This payment highlights the close relationship that we have with Allison, as well as the company's confidence in our progress to commercialisation," comments Steve Murray, Torotrak's product director for commercial vehicle main drive transmissions. And he adds that it's not just about Allison, either. Torotrak has now completed a substantial test programme with a major European truck and bus manufacturer it can't name, he says, but that also holds a licence for heavy duty applications. And the firm is also working with Tata Motors.

"A new investigation of performance in typical long-haul applications has delivered some very positive results," states Murray. "We've previously shown that fuel economy gains in city buses and distribution trucks of around 20% are achievable. Now we can also report that meaningful fuel



economy gains have been demonstrated against long-haul truck cycles, too.”

Coincidentally, its claimed fuel-saving benefits are similar to those also being touted for Torotrak’s flywheel-based MKERS (mechanical kinetic energy recovery system: *Transport Engineer*, October 2012, page 12). And Murray points out that, although the benefits of using both are unlikely to be wholly additive, there is a bright future for each of these CVT (continuously variable transmission) based technologies – and that includes in combination.

### Twenty per cent

Putting meat on the bones, though, Murray explains that a 20% improvement over conventional automatics is entirely realistic on stop-start and city urban cycles. That’s because the Tortrak drive eliminates power losses through the torque converter, as trucks and buses run up and down the gear range. However, on long haul, where that’s not the case (and he concedes diminishing returns on fuel economy), he argues that the latest IVT configuration delivers valuable improvements through its provision of a more effective overdrive.

What about fuel consumption benefits, compared to AMTs and manuals? Clearly, they’re not as great, although the fact of no gear shift or clutch losses, and an engine running within its optimal band at all times, still make a difference, he argues.

As for the precise configuration currently going forward for heavy-duty main drives, Murray explains that it’s similar to the design developed late last year. That’s based on Torotrak’s toroidal variator-based CVT (see panel), surrounded by a gear train that enables it to be swept three times over its ratio range (*Transport Engineer*, February 2012, page 22).

“We’ve got a direct connection to the engine output, followed by an epicyclic gear set with parallel split paths – part of the power running via the toroidal variator and part through a mechanical shunt, before being recombined and transmitted to

## Novel pressure charger packs promise

Trials on a new pressure charger, said to combine the best of supercharging with the best of turbo-charging, have confirmed that it slashes time-to-torque by up to 70%, compared with current single turbocharger technologies. The unit in question is Torotrak’s latest V-Charge variable-drive supercharger, and product director Andrew de Freitas says that testing on the 1.1 litre Renault Clio development vehicle has shown it to be capable of boosting torque from zero to 95% in less than 400msec – at any engine speed.

That’s around one third of the time required by the latest generation of heavily-downsized small turbocharged engines in the low-speed range. And hence the claim that V-Charge currently provides the only cost-effective route to affordable downsized engines. “In a downsizing application, a single turbo will deliver the required CO<sub>2</sub> reduction, but at the expense of significant areas of driveability,” reasons de Freitas. “A more sophisticated boosting system provides good driveability but with the cost and engineering issues that come with complex technologies.”

In fact, de Freitas explains that the new pressure charger gets around conventional engineering and cost problems by using a small, high-efficiency impeller, similar to a turbo, but driven via its compact variable drive – a gearless variable speed transmission that can change ratio from 0.4 to 2.5 within 250msec. This allows high boost to be provided on-demand at low engine speeds, giving instant throttle response, without the inefficiency of too much boost at higher engine speeds.

“Our test results, and the comments of specialists who have driven the development vehicle, confirm that V-Charge will deliver class-leading driveability at an affordable price,” states de Freitas. And although initially aimed at petrol passenger car engines – because that’s where the opportunity is greatest – he insists there is no reason why V-Charge shouldn’t be applied to diesel engines and for large commercial vehicles, because the concept is scalable.

Further, while heavy-duty commercial vehicles may not have a need for the instant pick-up that this pressure charger provides, Torotrak’s new development may deliver other benefits – for example, allowing further optimisation of combustion strategies.

And there is another point: the back pressure caused by increasing amounts of after-treatment on the run-up to Euro 6 is causing some concern among engine designers, who may eventually welcome the concept of taking a turbo out of the exhaust stream. This could help with stop-start applications, with improved catalytic converter light-off times.

the wheels,” states Murray. Clutches select between modes, with the first covering reverse and low forward speed, while second and third provide increasing gear ratios out to overdrive. “The inherent responsiveness of this set-up means the driver can move very quickly from high economy to high performance, with seamless gearing all the way.”

Now the \$64,000 question: when are we likely to see the transmission? Murray is cautiously optimistic: “We started at concept validation and, although there were many potential configurations, we have concluded that our initial approach was optimal. Although no production decisions have been taken yet, we hope this is just a few years away.” 