Compound INTEREST

A new long-haul package deal from Volvo, among other features, sees the return of turbocompounding, in which extra use is made of exhaust gases. The result is smooth power at low revs, finds Lucy Radley

Volvo Trucks' latest release, its FH tractor with I-Save, will, it says, save up to 7% on fuel costs over the standard spec D13 counterpart, thanks to a combination of changes. Aimed at those conducting very long haul operations – over 120,000km/year (75,000mi) – the main strategy is to keep the truck in as high a gear as possible at all times while driving at very low revs. That in itself is nothing new. But its method for achieving this takes a fresh approach that can broadly be split into two parts, perhaps the most interesting of which involves the engine.

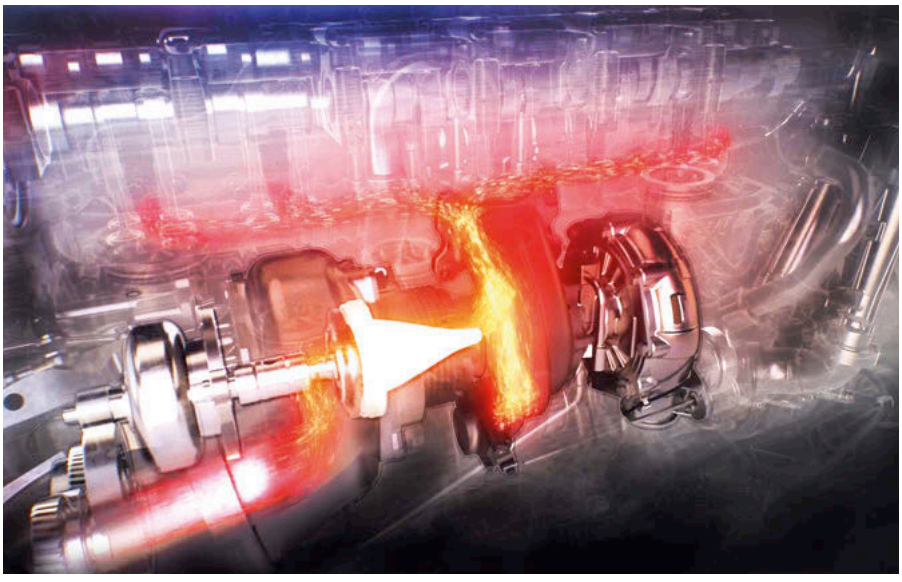
First is mechanical turbocompounding. While turbocharging uses the energy remaining in exhaust gases to boost air intake pressure into an engine, there is still more which could potentially be extracted and used. To harness this, a second turbine is placed in series with and downstream from the turbocharger, which in turn drives a gear linkage delivering the energy back to the crankshaft, increasing torque without using extra fuel (pictured, right; see video at *www.is.gd/igogul*).

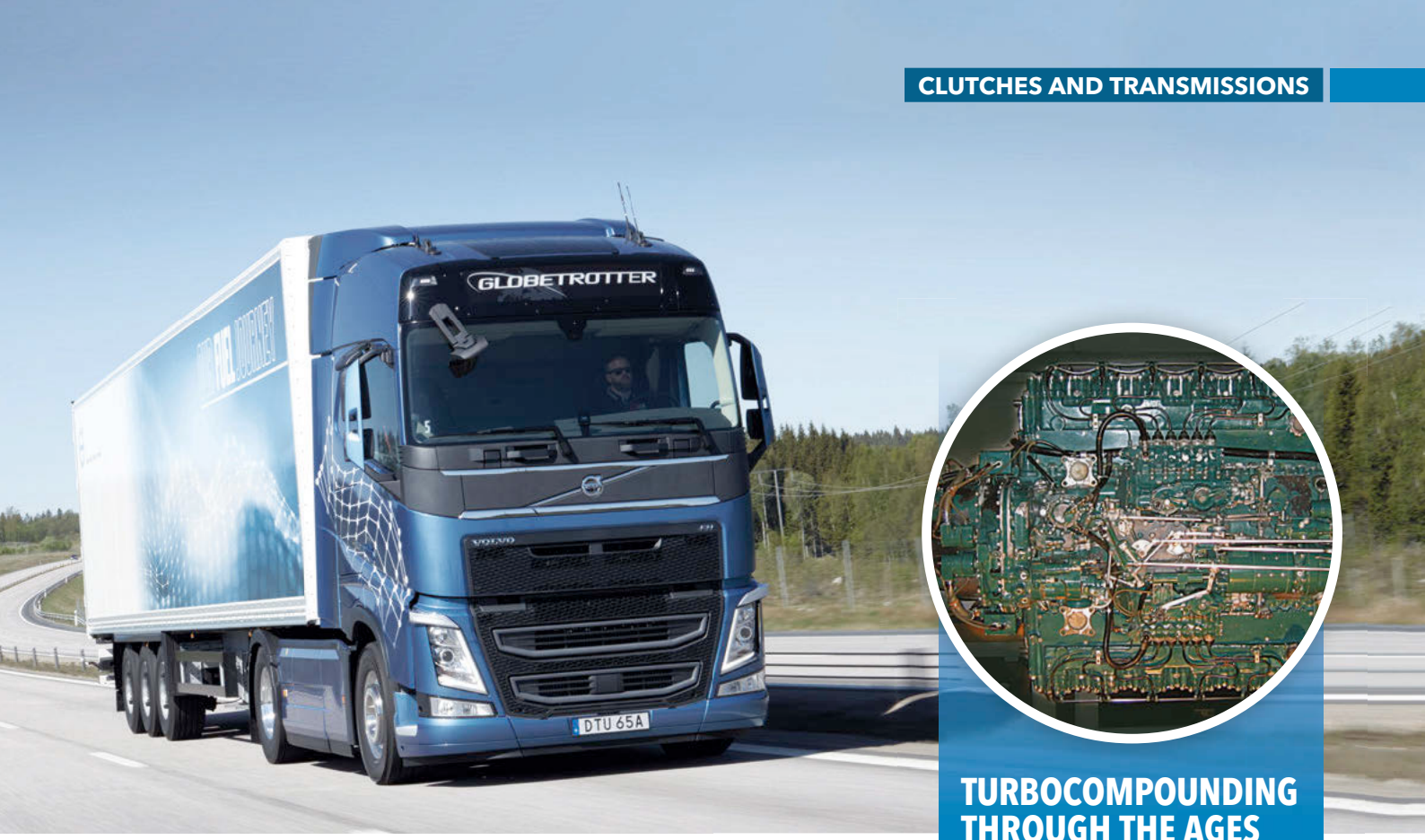
The introduction of EGR makes turbocompounding attractive for another reason: it generates a small amount of extra back pressure. Once upon a time, it was possible, by setting up the turbo correctly, to generate more intake pressure than exhaust, which effectively meant the engine assisted itself. But the advent of EGR brought a need to add pumps to the system to raise exhaust manifold pressure and ensure the gases flowed in the correct direction, and that also led to a reduction in power and efficiency. By placing a second turbine in the system, yet more back pressure is created, which means the main turbo can once again be brought far nearer to maximum efficiency, while the EGR is still forced to flow the right way.

The new Volvo D13TC will be sold alongside the updated D13, which is now Euro VI Step D ready. In the D13TC, an axial turbine is used to drive a geared linkage to the crankshaft, with a form of fluid clutch acting as a damper. There will inevitably be small differences between the speeds of the turbine and crankshaft, so damping those helps to ensure the longevity of the system.

OTHER CHANGES

But there are other changes elsewhere within the engine, too, not least of which





is a patented wave-shaped piston. "This has seven waves, so when the combustion flame hits the side of the piston, the waves lead the flame back to the centre of the cylinder where there is unused oxygen," explains Matz Franzen, Volvo ICE powertrain strategy director. "This helps to give more homogeneous combustion, while at the same time means more of that combustion takes place in the centre of the cylinder, so less cooling is needed."

The result of all this is an engine which, when compared to its non-turbocompounding counterpart with the same horsepower rating, produces an extra 300Nm of torque, and reaches the same power levels approximately 350rpm earlier. In the case of the 454bhp version for example, peak torque for the D13TC is 2,600Nm from 900-1,300rpm, as against 2,300Nm from 900-1,300rpm for the standard D13. Similarly, in the more powerful version, 493bhp is achieved at 1,250-1,600rpm in the turbocompound engine, against 1,530-1,800rpm for the standard engine. It is this difference that Volvo claims leads to fewer gear changes when climbing, increased use of the direct-drive top gear and the ability to drive on lower rpms in general, all leading to less fuel being used and a far quieter and smoother drive.

Cooled EGR – where the recirculated exhaust gases first pass through a cooling matrix before returning to the engine – is also now featured, apparently reducing AdBlue consumption from a ratio of around 8.5% of that of diesel to around 5-5.5%, another not insignificant cost saving for the operator. As a side note, the first generation of the D13TC, as sold in the US, only gave a 50Nm boost to torque, so this is a big step forward.

That last point, however, has produced the need for another new component, namely a faster rear axle. Rated at 12 tonnes, the new axle has a single reduction hypoid gear enabling multiple teeth to mesh simultaneously, increasing durability while at the same time resulting in a very quiet final drive. Also featuring a lower pinion offset, a higher efficiency bearing and lower oil volume, it is available in six ratios, from 3.36:1 to 2.31:1, the latter being considered ideal for long-haul operations. Combined with updated suspension, the whole assembly gives a weight saving of 100kg, which is just as well – the addition of both the turbocompounding system and cooled EGR to the new engine makes it 100kg heavier, so in combination the changes in axle and engine weights cancel each other out.

TURBOCOMPOUNDING THROUGH THE AGES

1950 Turbocompounding has been toyed with by many manufacturers over the years, including Volvo itself, which released a 12-litre version back in 2002 as a means to produce extra horsepower. Scania also played with the idea around the turn of the millennium to reduce NOx in Euro III engines, particularly with a view to meeting Austrian emissions standards, but this too was quietly dropped. Historically, turbocompounding was used in high-efficiency aero engines in the 1950s such as the Napier Nomad above, but they then evolved into far simpler turboprop and turbojet arrangements, cutting out the piston-driven element entirely. Much more recently, 10% of new heavy engines sold in the US for road use in 2011-12 featured **2002** turbocompounding, though this dropped back to 2% by 2015, mainly as a result of its abandonment by Detroit Diesel (Daimler) in favour of an asymmetric turbocharger. Meanwhile, Volvo has been **2011** producing an earlier version of **2015** today's D13TC for the US market for the past 18 months, and it is this **2019** tried and tested unit which has been upgraded to produce today's model.

Pic credit: Wikimedia Commons/Kimble D. McCutcheon via the Aircraft Engine Historical Society

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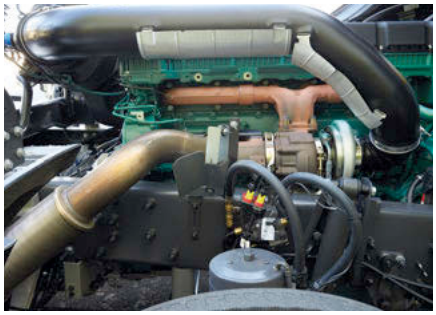


The final piece of the jigsaw – apart from the recommendation that I-Save trucks are run on Class A tyres for the lowest possible rolling resistance – is an updated version of Volvo's Long Haul Fuel Package software. This largely depends on map-based predictive cruise control system I-See, which was first introduced in 2012, and moved to a cloud-based mapping solution in 2017. Originally designed to improve gear selection in cruise, I-See 'shows' the truck hills and gradients ahead using GPS, including those out of sight of the driver. This enables the software within the I-Shift automated manual gearbox to optimise the amount of time it can spend both at higher gears and with the drivetrain disengaged completely – a function Volvo calls I-Roll, but which is colloquially familiar to most as Eco-roll. This includes before the vehicle reaches the peak or crest of a hill when the system can 'see' there is enough momentum so that further power is not needed. This is, of course, not unique, with all seven manufacturers offering predictive cruise on their current models: Mercedes-Benz, for example, claims the potential for a 5% fuel saving based on use of its predictive powertrain control alone.

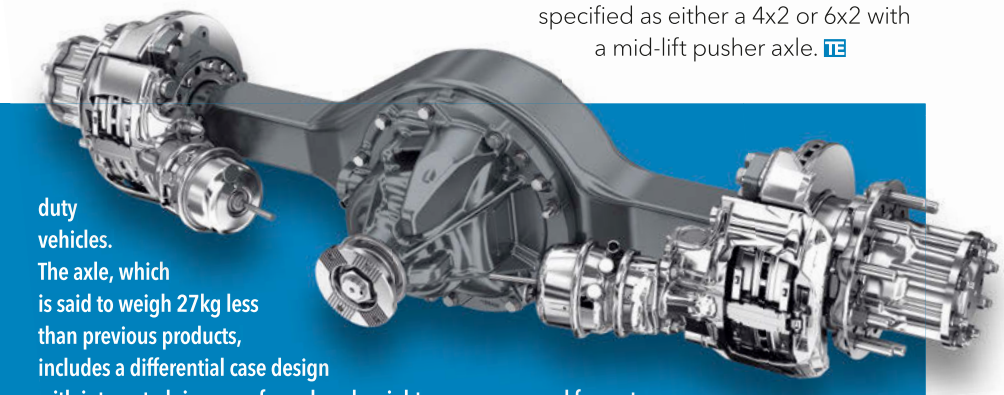
PEDAL FEEL CHANGED

Perhaps the biggest change in this latest iteration of I-See, however, is that it is also effective when the truck is being driven on the throttle pedal, rather than just in cruise. This includes improved calibration on the pedal itself, giving greater control at low speeds and when manoeuvring. Both of these are immediately obvious on test drive, as is the undeniable difference made by the addition of turbocompounding to the D13TC engine (pictured, above right) – this powertrain really does allow the truck to keep pulling all the way down to 900rpm without any sign of labouring, and the smoothness of the ride is far more noticeable than expected.

It is, however, as Volvo itself concedes, difficult to prove that 7% overall fuel saving over a 300km test route, as so much is dependent on the terrain that the vehicle is covering and the manner in which the driver does so. For reference, that 7% figure is based on the whole I-Save package – so the turbocompounding engine, updated I-Shift transmission software, updated I-See, I-Cruise, the lighter 12-tonne drive axle, speed-dependent air-suspension, Class A tyres and a new power steering pump. On the test trucks driven, Volvo had fitted Michelin X-Line tyres. Also, the benefit is compared against the D13 eSCR Euro VI Step D, which seems to mean a vehicle with the non-turbocompounding version of the same engine (pictured, above left), and without any of the extra components detailed above.

The new Volvo I-Save is certainly impressive on paper, and feels impressive behind the wheel, but whether it delivers in the long run only extended operation in the real marketplace will show. The Volvo I-Save is available for order in right-hand drive for the UK market as of now, and can be specified as either a 4x2 or 6x2 with a mid-lift pusher axle. TE

AXLE ALTERNATIVE



At last year's IAA show in Germany, Dana launched a low gear ratio axle intended for heavy-duty downspeeding applications that seems similar to Volvo's new 12t I-Save rear axle. The Spicer 175 Series single drive axle offers what it calls the industry's lowest numeric gear ratio, 1.95:1, for optimum engine downspeeding. Ratios go up to 3.42:1. It also says that the axle is ideal for European heavy-duty vehicles. The axle, which is said to weigh 27kg less than previous products, includes a differential case design with integrated ring gear for reduced weight and oil churning losses, AdvanTEK gearing and autonomous lubrication system. The axle is approved for up to 52t gcw applications, and engines up to 592bhp producing torque of up to 2,750Nm.