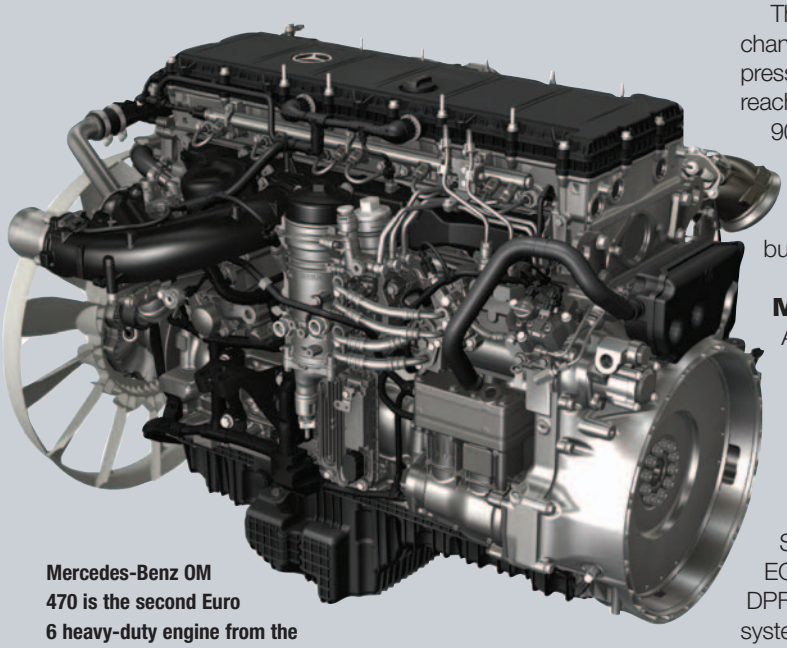
Euro 6 of the

The upcoming introduction of Euro 6 engine emissions legislation is prompting a growing number of truck and bus engine manufacturers to unveil their solutions. John Challen and Brian Tinham investigate latest offerings from Mercedes-Benz, Cummins and DAF

The European engine emissions standards for medium and heavy commercial and passenger carrying vehicles are on the brink of their sixth incarnation. January 2013 is the deadline for newly type approved trucks and buses – and just 12 months later all new registrations will have to conform. So, with a matter of mere months to go, formerly coy engine manufactures are now revealing their prized solutions to the challenges of ultra-low NOx and particulates posed by Euro 6.



Mercedes-Benz OM 470 is the second Euro 6 heavy-duty engine from the German manufacturer, after its OM 471

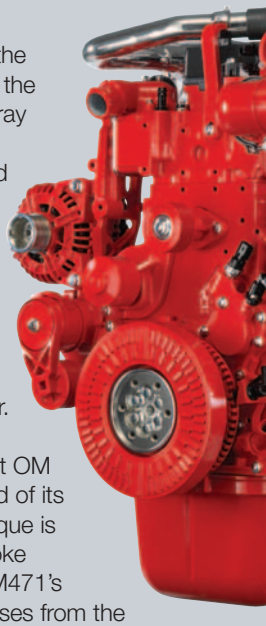
Let's start with Mercedes-Benz – and having launched its first Euro 6-compliant engine (OM 471) in the spring of 2011, Mercedes-Benz recently revealed its stablemate, the 10.7-litre OM470, which offers outputs from 326 to 428bhp. The covers were also taken off the company's new engines for light- and medium-duty trucks, as well as buses and coaches. The latter, dubbed OM 93x, are set to come in four- and six-cylinder formations, with displacements of 5.1 or 7.7-litres respectively, and offering outputs between 156 and 354bhp.

Georg Weiberg, VP of truck engineering at Daimler, says the biggest challenge during development of both engine series was meeting Euro 6's tight limits on NOx and particulates, while simultaneously maintaining or reducing fuel consumption. On the face of it, optimising engines for the former could only be done by sacrificing the latter – and, on the way, also increasing CO_2 emissions. "Everyone seemed resigned to the conclusion that, with Euro 6, fuel consumption would go up," he recalls. "But we made sure that with our technology and engineering we could hold, or even reduce, fuel consumption."

The OM 470's Bosch common rail kit is one of those game-changing technologies. It features that manufacturer's X-Pulse pressure booster, which enables pressure at the injectors to reach 2,100bar, despite maximum pressure in the rail running at 900 bar. Depending on operating conditions, injection rates can also be customised, with each injection cycle comprising up to five individual injections. Benefits include a smooth-running engine, as well as help in maximising the burn and reducing fuel consumption.

More than meets the eye

As for the injectors themselves, the design is the same as in Mercedes' earlier OM 471, with the same seven injection orifices, but a new spray nozzle shape. Also, the geometry of the combustion chamber has been re-optimised for this engine – as has the emissions management technology. Yes it harnesses SCR (selective catalytic reduction), cooled EGR (exhaust gas recirculation) and an active DPF (diesel particulate filter), but the latter two systems are altered. On the one hand, the water manifold on the EGR cooler has been eliminated; on the other, the particulate filter is new and lighter.



But that's far from the full picture. The OM 470 achieves performance similar to Mercedes' current OM 457, yet from a displacement of 10.7 litres, instead of its predecessor's 12 litres. Further, near full (95%) torque is available at just 800rpm, partly due to its long-stroke (bore/stroke ratio of 125/145mm), but also the OM471's asymmetric turbocharger, which takes exhaust gases from the rear three cylinders, without losses from passing through the EGR system. And it's smaller and more robust (with a crankcase made from special cast-iron alloy, cylinder head from

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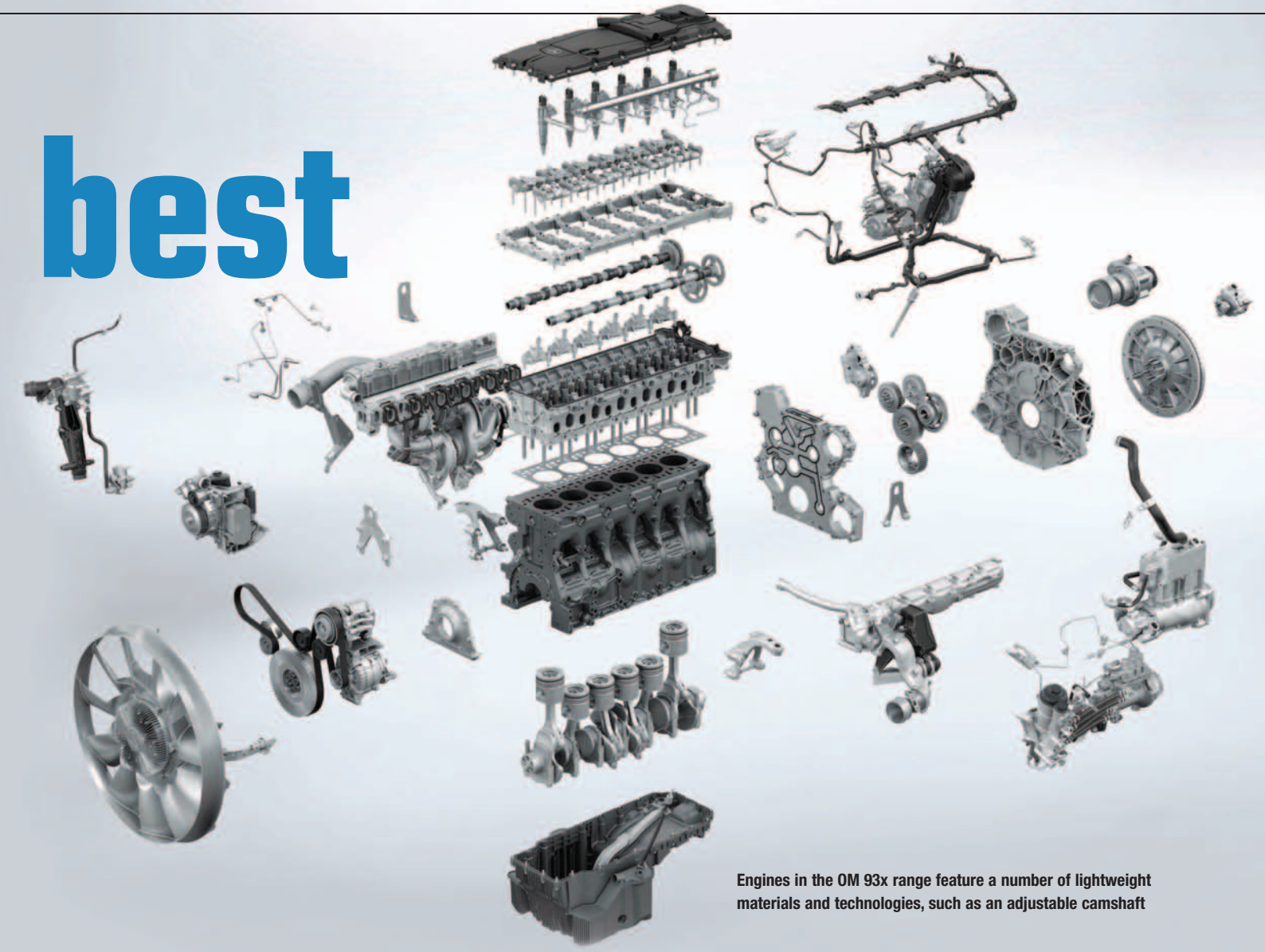
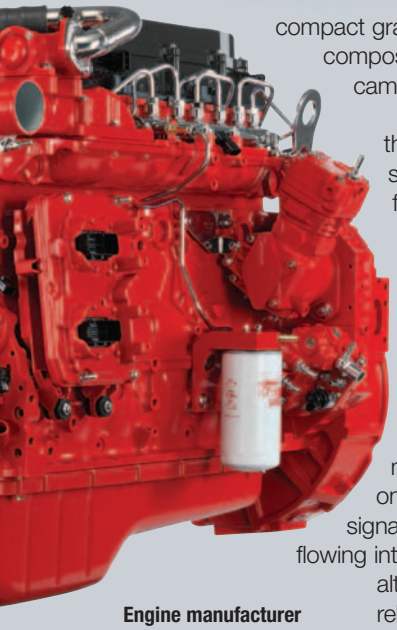


Engines in the OM 93x range feature a number of lightweight materials and technologies, such as an adjustable camshaft



Engine manufacturer Cummins has debuted Euro 6 engines for truck and bus applications

compact graphite iron, steel pistons and composite, lightweight double overhead camshafts), yet weighs in at 50kg less.

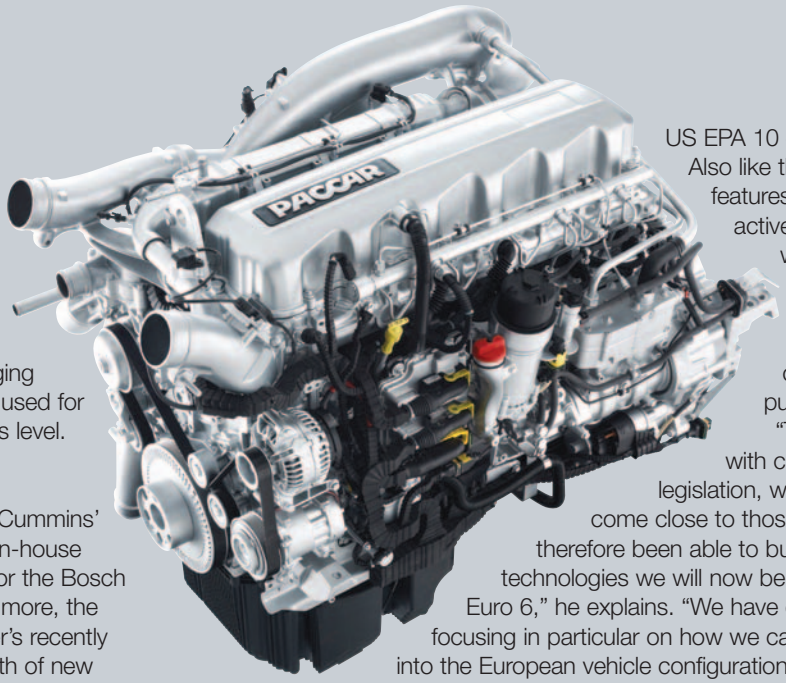
Meanwhile, the OM 93x range is the first Mercedes-Benz CV engine series where every unit meets Euro 6 from the outset. One highlight is the first use, in series-production diesel engines, of an adjustable camshaft. If regeneration is needed, timing can be adjusted by up to 65° to 'early' – meaning that the exhaust valves open and close earlier, so the exhaust gas released from the cylinder is hotter. The adjustment is made hydraulically via a vane piston on the exhaust camshaft, acting on a signal from the ECU – with engine oil flowing into the vane piston, which turns to alter the position of the camshaft, relative to its drive gear.

This engine itself uses a crossflow cylinder head, with four valves per cylinder, and intake and outlet valves arranged in parallel pairs. That formation keeps the intake and outlet ducts as short as possible, so minimising flow losses and fuel consumption. The cylinder head and crankcase have also been robustly joined: the former is formed from grey cast iron with lamellar graphite (GJL), developed by Mercedes-Benz in Mannheim, and claimed to give exceptional strength and thermal properties.

Other key elements include the rigid crankshaft and crankcase – the latter using a supporting spar structure, made out of the same material as the cylinder head. That's what enables the high combustion pressures, while at the same time reducing noise. It's a similar story with the way the crankshaft drives the camshafts – which is via a compact and rigid gear drive on the back of the engine. Gear wheels on the flywheel side of the engine help reduce noise, while also driving an unusually compact arrangement of auxiliary units.

Injector technology differs to that adopted in the OM 470 – with a single-stage Delphi unit giving pressures up to 2,400 bar. Again, based on a common-rail design, the unit comprises an oil-lubricated, high-pressure pump and centrally positioned injectors, and enables up to five individual injections per cycle.

And turbocharging is also different, with Borg Warner providing units optimised for each engine output category. In the four-cylinder OM 934, pressure for output up to 177bhp



comes from a single-stage exhaust gas turbocharger. Two-stage turbocharging is then used for the higher outputs. The six-cylinder OM 936 uses an asymmetric exhaust gas turbocharger with double-flow turbine for outputs up to 299bhp. Two-stage charging with twin turbochargers is then used for the output categories above this level.

Cummins' latest creation

In contrast to Mercedes-Benz, Cummins' Euro 6 engines feature entirely in-house developed components, save for the Bosch fuel injector technology. What's more, the heavy-duty engine manufacturer's recently unveiled engines feature a wealth of new technologies that again reach the all-important emissions limits, while also maintaining similar levels of fuel economy. That said, Cummins concedes that, rather than developing brand new engines, the firm has focused on making improvements to its existing ISB 4.5 and ISB 6.7 units.

First up, the 4.5-litre ISB 4.5 (with 210bhp and 760Nm) was designed and developed in the UK, although it is produced at Cummins' Beijing plant. Already proven in trucks up to 18 tonnes and buses up to 12m-long, the Euro 6 version of this engine merges the best of its Euro 5-compliant predecessor with the firm's recently launched ISF 3.8, and US EPA 2010 emissions handling technologies.

Weight has been saved by using composites for the oil pan and valve cover, while the block and head are 10% and 20% lighter respectively, with a claimed zero loss of durability. A split-exhaust manifold has also been adopted for the benefits it brings, in terms of thermal management, while a maintenance-free breather system, integrated into the camshaft, is the choice for crankcase ventilation.

Then the 6.7-litre ISB 6.7, which offers 310bhp for truck and coach applications and 280bhp for buses, delivers peak torque of 1,100Nm – the same as its forerunner. The biggest changes here are in the EGR and turbocharger technologies. EGR has been redesigned for cab-over applications, while Cummins' VGT (variable geometry turbocharger) is now optimised for European conditions, with high torque and low speed capabilities. Both developments bring performance and driveability benefits, as well as emissions reduction. The VGT can also operate as an exhaust brake, and both it and the EGR system are controlled by new OBD kit.

Like the smaller Euro 6-compliant Cummins engine, ISB 6.7 has a new closed crankcase ventilation set-up, this time mounted to the engine valve cover. There is also a new filter on the engine, developed using nanotechnology, to protect the engine's fuel system, removing up to 98.7% of all particles, right down to four microns.

Moving on to DAF Trucks, its new entrant for the Euro 6-ready market is the 12.9-litre Paccar MX-13 engine. Like the Cummins unit, the base engine has its origins in the US, where it is more commonly referred to as the Paccar MX, which meets US EPA 10 emissions standards. Also like the Cummins unit, it features a VGT, as well as an active soot filter, both of which work in tandem with SCR and EGR to ensure it is, as Ron Borsboom, DAF head of project development) puts it, ultra clean.

"This engine complies with current North American legislation, whose emission values come close to those of Euro 6. We have therefore been able to build up experience of technologies we will now be applying in Europe for Euro 6," he explains. "We have developed these, focusing in particular on how we can best integrate them into the European vehicle configuration," he adds, citing a raised position for the EGR cooler, which allows the turbo to be placed closer to the block, so also reducing the engine size.

"This is an important factor when it comes to fitting the engine in our European cab-over-engine vehicle designs: it allows for a low cab floor to ensure ease of entry and maximum cab space... We will also be applying technologies that have been introduced as part of our ATe programme for Euro 5." Examples include an encapsulated exhaust manifold, for even better turbo efficiency, and optimised piston rings and cooling."

Core component alterations

The MX-13's block has also been redesigned for greater stiffness and, like the cylinder head, is now cast in compact graphite iron. And that's not all: "With a view to ensuring maximum reliability and durability, as many functions as possible have been integrated," says Borsboom. "For example, plumbing has been cast into the cylinder block and head, and the two pump units that generate pressure in the common rail system have also been integrated, which means they can be actuated by the same camshaft that drives the valves. Also, fuel in the central pipe is supplied using smart dosing controls to ensure optimum efficiency by only compressing the fuel mix needed."

As for MX-13's common rail system, this allows injection pressures up to 2,500 bar with pre- and post-injection, or a combination. The point: higher pressures result in finer atomisation, while multiple injections enable optimised combustion, ensuring the lowest possible emission and noise levels, and lowest possible fuel consumption. And furthering those causes are a range of other developments, such as: the single poly-V belt and fan, mounted directly on the crankshaft without a coupling shaft; a larger oil sump, made of composite material and allowing service intervals of 150,000 km; and a combination fuel filter and water separator, mounted directly on the engine for ease of maintenance.

DAF's engine is due to enter production early in 2013, with outputs of 410bhp, 460bhp and 510bhp. "Obviously, the introduction of new and additional Euro 6 technologies will have consequences for our vehicles," concludes Borsboom, confirming that more information will be revealed at Hannover's IAA Show in September. TE