ADVANCE

Engine brake technology has seen little change in recent years. However, with its revolutionary two-stroke compression brake design, Jacobs Vehicle Systems is rewriting the rules. Brian Tinham explains

Engine brakes have been around on heavy-duty trucks for decades. Indeed, the good old Jake Brake goes right back to 1961 and best estimates put the number of HGVs in the UK today equipped with engine brakes of one kind or another at no less than 90%.

Unsurprisingly then, most of us are familiar with their function, if not their detailed operation. It's about using the engine to enhance deceleration, mostly by altering exhaust valve operation so it flips to become a power-absorbing air compressor. Retarders using hydraulic turbines are the other main contender, usually integrated via the transmission.

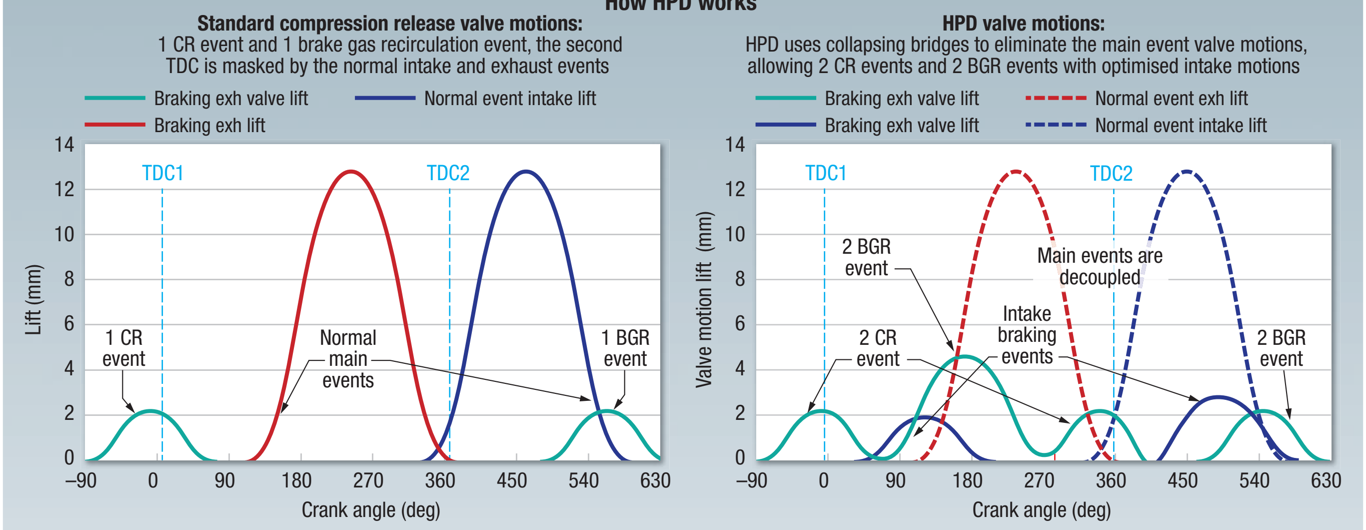
So, why should our interest suddenly be rekindled in fitments that are hardly remarkable for rapid strides in engineering? Well, because all that is about to change. Latest technology, just launched, looks set to deliver a step change in retardation power, even at previously problematic slow speeds and low engine revs.

NEW ENGINE EQUATION

What's more, it does so without cooling, and with virtually no weight penalty. Quite simply, the standard cost-benefit equation for engine brakes – purchase price versus improved foundation brake life, truck uptime and better residuals – is being rewritten.

A few weeks ago Jacobs Vehicle Systems – JVS, an acknowledged global leader in this field – launched what it describes as next-generation engine braking technology at Millbrook Proving Ground. To demonstrate its game-changing power, journalists were invited to witness the contrast between two Euro 6 Mercedes-Benz Actros tractor units, one mounted with its existing compression release brake (CRB, as specified by OEMs including DAF, Mercedes-Benz and Volvo throughout Europe), the other with its new HPD (high power density) version. The

How HPD works

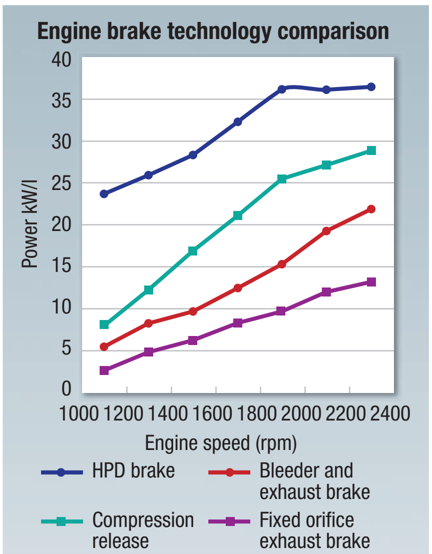


RETARD

difference was impressive.

HPD achieves the same retarding performance at 1,200 rpm as previous-generation engine brakes did at 2,100 rpm – 27kW per litre. That translates to a 100% increase in engine braking power at cruise speeds. Just as important, the new variant offers more than twice the engine braking performance at low rpm than traditional CRB equipment.

As JVS technical director Tom Howell puts it: "This equipment provides large displacement retarding power in small and medium displacement diesel and natural gas engines." That tells us why it was developed, too. Howell reckons that HPD solves engine braking issues that are an unintended consequence of OEMs' and engine suppliers' drive to deliver better fuel economy by developing smaller, higher power-density engines and more aerodynamic cab designs.



UNINTENDED CONSEQUENCE

"Key strategies for improving fuel efficiency are reducing the natural retardation of the vehicle caused by wind resistance, engine, drive train and friction," he explains. But that means reduced retardation potential. So the new engine brake plugs the gap. And the same goes for trucks running natural gas engines, whose smaller turbochargers and lower compression ratios can cut engine brake power by up to 25%. "HPD compensates for this loss."

Yet the new device apparently weighs 175kg less than a traditional retarder (12 additional rocker arms and associated equipment) and JVS says total cost of ownership will also be €3,500 lower. What's more, the company predicts that fleet operators might expect a return on investment within six months. Compare that to an average of two and a half years for hydraulic retarders.

Why? It's not rocket science: JVS's HPD uses standard components, which are neither expensive nor heavy. That said, we're talking about ground-up OEM integration for each engine. So for the foreseeable future this is not retrofit equipment. Indeed, although the Millbrook conversion was on a Mercedes-Benz OM-471 six-cylinder inline power unit, JVS is unable to say whether even this will move on to see production.

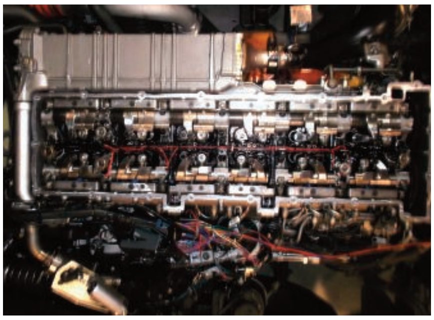
"This equipment provides large displacement retarding power in small and medium displacement diesel and natural gas engines"
Tom Howell

So, how does HPD make its difference? It's all about two-stroke compression release. In this design, instead of one compression release event per cylinder cycle, there are two. The second compression release event is effectively the same as for the first (compression stroke), in terms of TDC (top dead centre) timing, because the main intake and exhaust valve events are deactivated, using collapsing bridges. This is the clever bit. It enables a build-up of engine-retarding pressure in the cylinder for a second TDC event. Clearly, since there are now two compression release events for each engine cycle, retarding power is significantly increased.

"At the engine level, hydraulic solenoids under the valve cover are activated by the ECU, so enabling the changes in valve motions and timing"
Tom Howell

In detail, the second (exhaust stroke) HPD compression release event involves supplementary valve actions enabling what amounts to brake gas recirculation intake from the exhaust manifold. This enables the cylinder to fill and hence maximise compression. Decompression is then achieved by opening the exhaust valves near the top of the compression stroke, releasing air through the exhaust system.

Howell says the increase in retardation power is achieved without exceeding any engine limits that constrain conventional engine compression release power – such as cylinder pressure – because there are twice as many engine retarding events. "From a driver's perspective, it's the standard approach: when the retarder stalk is on, if his or her foot is off the pedal, the engine goes into retarding mode. But at the engine level, hydraulic solenoids under the valve cover are activated by the ECU, so enabling the changes in valve motions and timing."



Jacobs Vehicle Systems' new High Power Density engine brake valvetrain revealed

As the cycle repeats, the truck's kinetic energy can now be dissipated almost entirely without assistance from the foundation brakes – despite engine downsizing. "Because we are enabling twice as much air to be compressed through the engine, the system works efficiently, even at very low rpm," says Howell, although conceding limits at high speed, which require the ECU to back off the wastage or VGT (variable geometry turbocharger) to avoid cylinder over-pressure.

In fact, with HPD Howell says the engine brake is typically capable of meeting 85% of a vehicle's braking needs. He also claims that the new unit enables faster controlled downhill speeds, which in turn maximise truck productivity. And he says that also means improved slowing times and reduced stopping distances, stating that a heavily loaded truck can be slowed from 90–70kph (56–43mph) in 30% less time and distance, with massively reduced friction brake wear.

Want a piece of the action? You'll have to wait a while. Howell explains that, because of the scale of engine integration, development timeframes are three to four years. "A lot of OEMs are talking to us, but so far less than five are in development," he says coyly.

Near-death experience

The first compression release engine brake was patented in 1961 by Clessie Cummins, who had founded Cummins Engine in 1919. When in 1955 he retired as chairman, he recalled a terrifying experience back in the summer of 1931.

He and two colleagues were driving a Cummins diesel-powered Indiana truck from New York to Los Angeles in an attempt to break the truck speed record. On day five they reached the top of Cajon Pass on Route 66 and began the 35-mile descent towards the San Bernardino on a gravel road criss-crossed by a railway. The brakes overheated and, although Cummins tried to slow the runaway truck with engine compression, he could not engage anything lower than third. That's when he saw a freight train a short distance ahead. He later said they missed the rear of the train with inches to spare.

By 1957 Cummins knew he could revolutionise engine braking by taking advantage of the timing built into Cummins and Detroit Diesel engines, with their third cam on the main camshaft, which activated the fuel injector for each cylinder. He would effectively transfer this motion to open the exhaust valve using a retrofit mechanism.

Clessie Cummins approached Cummins Engine but, when his design was rejected, he approached the then Jacobs Manufacturing Company. The rest, as they say, is history.