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Truck Engine Tech

Balancing energy efficiency with performance

By Gary Witzenburg

Once upon a time, when working trucks were rude and crude and completely task-focused, all truck engine engineers had to worry about was making sufficient torque, hauling power, and anvil-tough durability. Then came ever-toughening emissions and fuel-economy requirements, followed by increasing demand for refinement as Americans traded cars for pickups and SUVs, for transportation and weekend recreation.

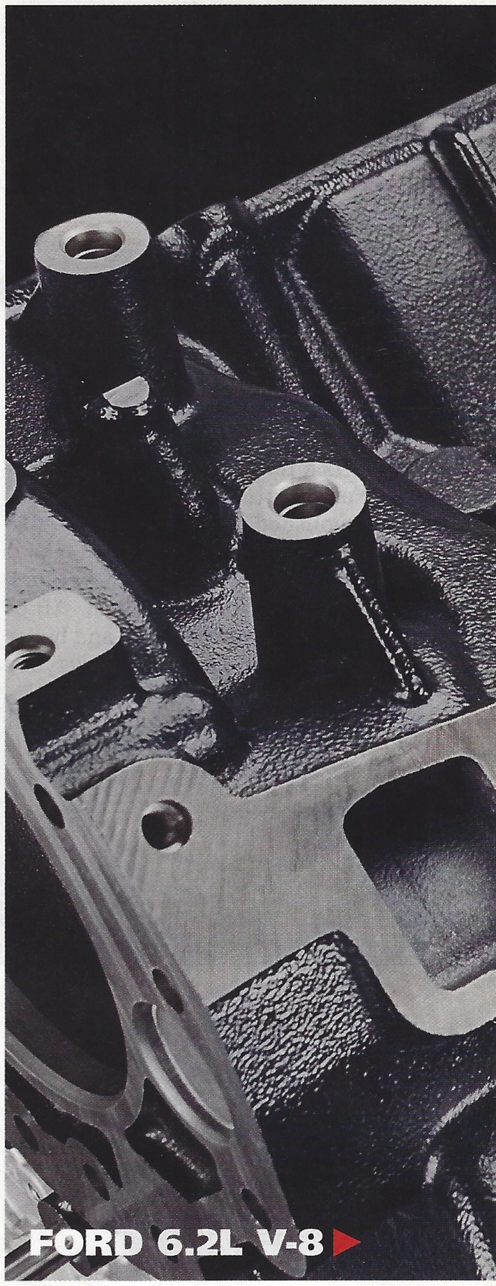
So the lives of those engineers keep getting more challenging. The competitive pressures for power and torque on one hand and luxury, comfort and quiet on the other remain intense, while fast-accelerating emissions and economy requirements must be satisfied.

To understand the technology directions being taken by today's truck engine engineers to meet these oft-competing demands, let's look first at two very different 6.2-liter gas V-8s.

6.2-LITER V-8

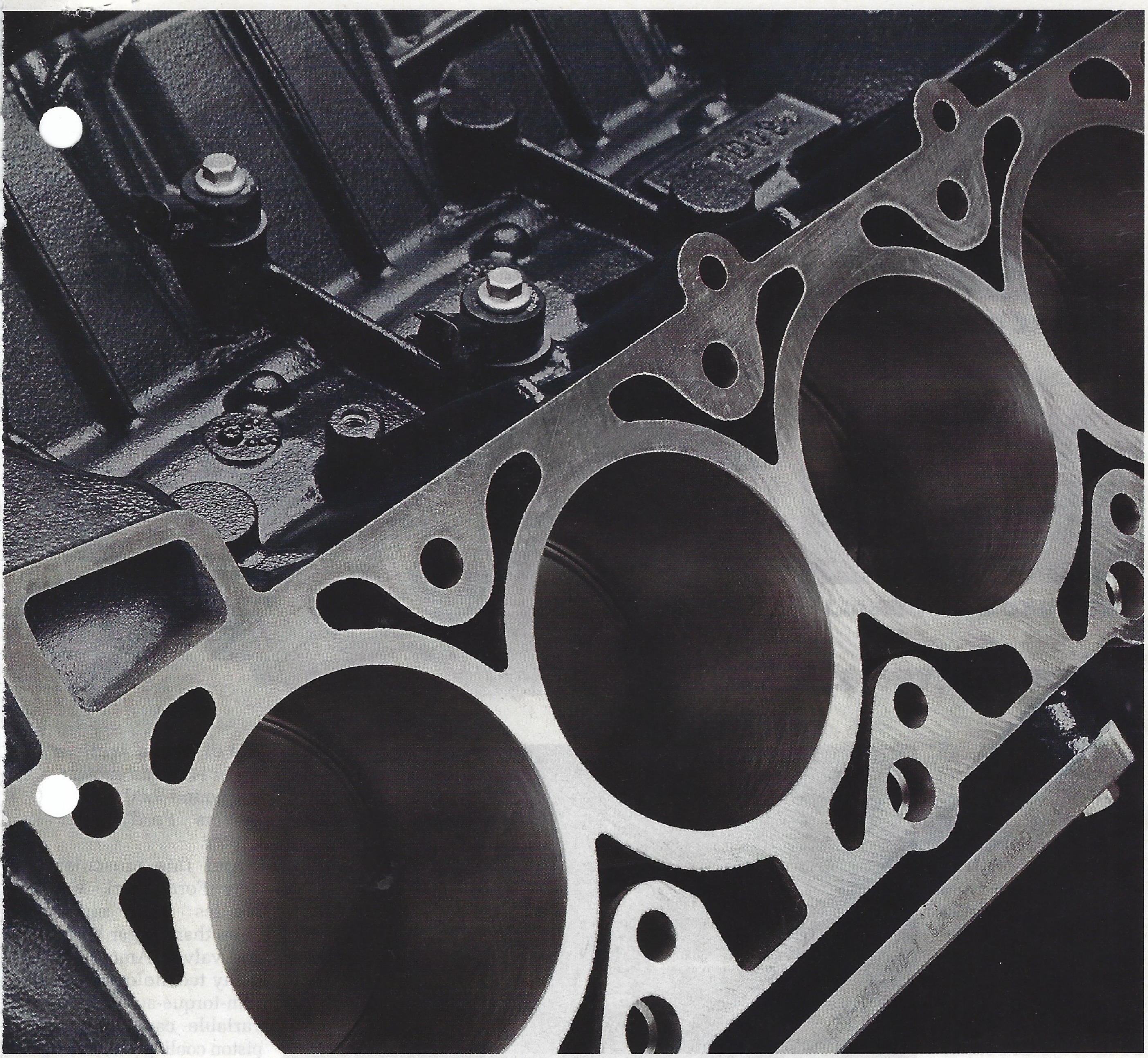
General Motors' 6.2-liter V-8 is the largest Gen IV small-block engine found in 2010 GM light-duty pickups and SUVs. A compact cam-in-block (CIB) V-8 (with its valves driven by pushrods riding roller lifters on a single camshaft buried deep in the block), it boasts a lightweight aluminum block and new-for-2010 variable valve timing (VVT), which GM calls cam phasing. With a fairly high compression ratio of 10.5:1, it generates 403 horses, 417 pound-feet of torque, and EPA economy ratings of 13 mpg city and 19 highway in 2WD pickups.

The versions used in GMC Yukon and Cadillac Escalade SUVs also have Active Fuel Management (AFM), GM's version of cylinder deactivation, which shuts down half the cylinders (by disabling lifters) to save fuel during light-load operation. And GM recently announced an $890 million investment to build its next-generation



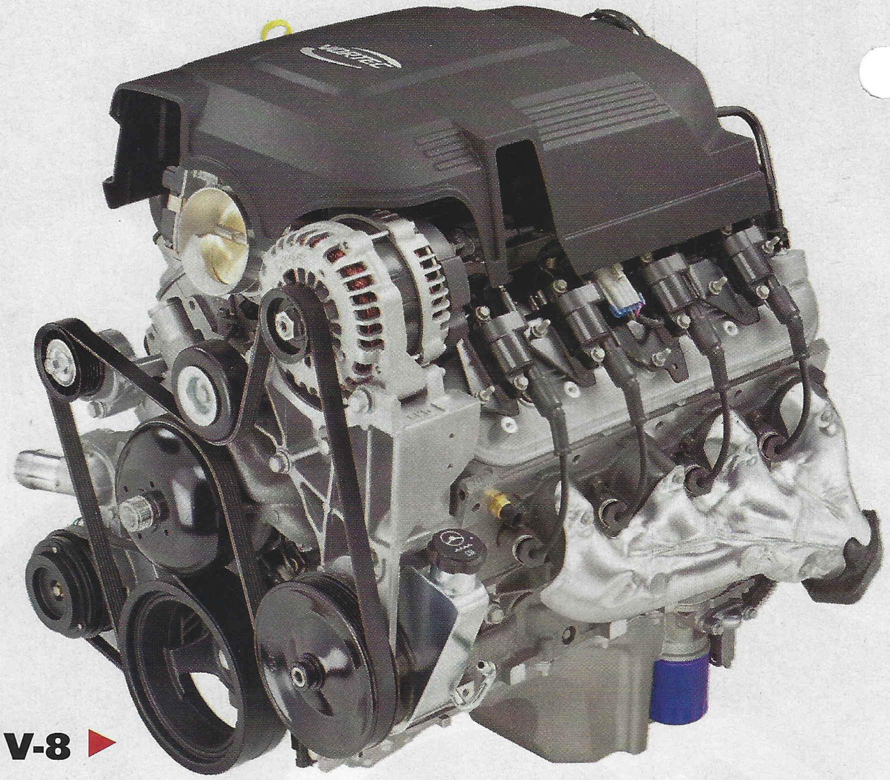
FORD 6.2L V-8 ▶

FORD RAPTOR



CADILLAC ESCALADE EXT

GMC YUKON XL DENALI



2010 VORTEC 6.2L V-8

GMC SIERRA DENALI

small-block V-8s, all of which will use an "all-new advanced combustion system design," plus aluminum blocks, cam phasing, VVT and the U.S. truck market's first application of high-pressure gasoline direct injection (DI).

"By the time you aluminize it, cam-phase it, AFM it, and DI it," says GM small-block chief engineer Dean Guard, "you're well on your way to balancing fuel economy, driveability, and performance, as well as Uncle Sam's emissions and diagnostic requirements." But GM won't reveal how soon we'll see these new "Gen V" V-8s. "We have not tied it to a model year," Guard says. "We're still working on the rollout. But you can probably guess."

Ford's all-new truck V-8 of the same displacement is substantially different. For starters, it boasts single overhead camshafts and two spark plugs per cylinder with aluminum heads on a cast-iron block. "We needed a bigger bore, and that enabled us to increase the valve sizes, which helped us make the power we needed," says Ford engine systems engineer Jim Stevens. "We couldn't get there with the architecture we had, so we needed a new architecture." Not available (yet) in light-duty trucks, it made its debut this year in F-250 Super Duty pickups, where it generates 385 horses and 405 pound-feet of torque, while a hotter (411 horsepower, 434 pound-foot) version powers Ford's SVT Raptor.

And this muscular new Ford truck V-8 bristles with much more than bigger bores and valves. Among its many technologies are cam-torque-actuated variable cam timing, piston cooling jets, and a stiff, low-friction roller-rocker-shaft valvetrain. "The VCT," Stevens points out, "uses cam torsionals, the small back-and-forth forces as the cam rotates, to help move it relative to the VCT phaser, which allows us to make the oil pump smaller." The cooling "squirters" on the undersides of the pistons enable more aggressive spark and slightly higher compression (9.8:1) for both power and fuel economy.

5.7-LITER V-8

Another pair of very different same-displacement engines are the Chrysler group's Ram Hemi V-8 and Toyota's Tundra V-8. Like GM's small-blocks, Chrysler's CIB Hemi V-8s use roller cam followers, variable valve timing, and cylinder deactivation (in Ram 1500s), which Chrysler calls its Multi-Displacement System. They feature Chrysler's famous semi-hemi (not quite completely hemispherical) combustion chambers. The Ram truck Hemi generates 390 horses, 407 pound-feet of torque, and

RAM POWER WAGON

14 mpg city, 20 highway fuel economy (with 10.5:1 compression) in 2WD light-duty trucks and 383 horsepower, 400 pound-feet (with 9.6:1 compression and no MDS) in HD Rams.

By contrast, Toyota's Tundra aluminum 5.7-liter is a DOHC, 32-valve V-8 with roller finger followers and dual (separate intake and exhaust) VVT, plus an intake manifold valve that switches from long runners for maximum low-end torque to short ones for max power, and a cooling water manifold between the cylinder banks that helps equalize cylinder temperatures. It also features piston cooling jets and four NOx sensors (versus the typical two) to help optimize spark timing. With 10.2:1 compression, it's good for 381 horsepower, 401 pound-feet, and 14 mpg city/18 highway 2WD EPA economy ratings.

▲RAM 5.7L HEMI TRUCK ENGINE

FUTURE IMPROVEMENT

With Corporate Average Fuel Economy and emissions requirements ramping up relentlessly in future years, there will be no rest for truck engine engineers. "Performance in an internal combustion engine comes from improving airflow, reducing parasitic losses, and improving combustion efficiency," says one Ram engineer. "On the airflow front, reducing flow restrictions, changing valve timing, and pressure charging all can yield benefits.

To optimize within the constraints of fuel economy, emissions, durability, and noise, it is necessary to understand the most minute details of engine operation, which is only possible through sophisticated modeling of every aspect of engine operation."

Everyone agrees there still is room for improvement in friction reduction, combustion efficiency, and some other areas. "We've picked the low-hanging fruit," says Toyota senior powertrain engineer Dan Yerace, "but there's still some fruit there. We'll have to stretch a bit further than we have.

"One thing we're looking at is smarter, demand-based systems for cooling and lubrication, instead of pumps running all the time regardless of demand. The challenge for pickups is that the majority of them, now more than ever, are used for work purposes, towing, and hauling heavy loads—but sometimes they're empty. It's very challenging to have enough performance to do the work but still get the efficiency." He adds that some efficiency tricks from the company's high-efficiency hybrids might eventually be "supersized" for truck applications.

Ford's Stevens tells us his new 6.2-liter V-8 is "protected for a lot of technologies, including direct injection and switchable valvetrains"—which can change cam profiles between one tailored for idle and low speed torque and another for increased power, or shut down cylinders to increase fuel economy—as well as for growth to higher displacements.

"There's a general trend toward more control of the valvetrain," says GM's Guard, "in both timing and lift. Everyone is looking at better thermal management, including using generated BTUs to heat fluids whose viscosities change with temperature to reduce frictional losses, allowing engines to run hotter, and using thinner oils to reduce oil pump losses while retaining bearing film thicknesses. How do we make water pumps and accessories more efficient? Should we get rid of power steering pumps and go to electric power steering?"

While we haven't discussed today's heavy-hauling turbodiesel truck engines, they will also need to ramp up their usage of enabling technologies to get ever cleaner and more efficient while improving, or at least retaining, heavy-duty truck capabilities. The truck engine technology trick is achieving the most effective balance of attributes and capabilities. The major challenge is to pull out all the proverbial stops to get the job done—yet keep it affordable. *TT*