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FORD HARLEY-DAVIDSON F-150

NEW DESIGN, AND A 411-HP 6.2L V-8

A SOURCE INTERLINK MEDIA PUBLICATION

Heavy-Duty Diesel Technology

State-of-the-Art Workhorse Diesels Are More Powerful and Fuel-Efficient Than Ever

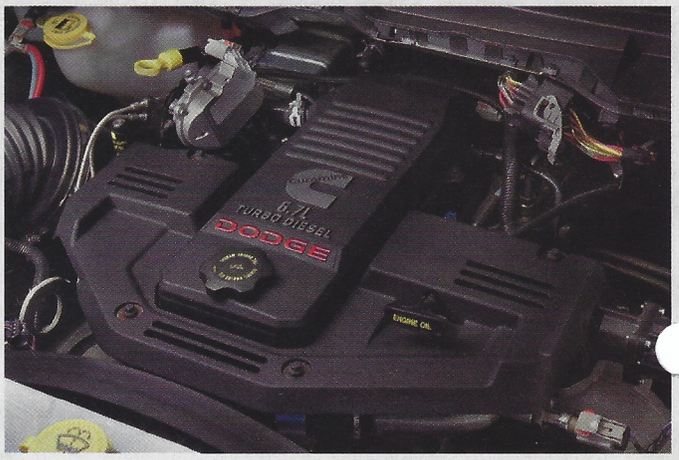
By Gary Witzenburg

Rudolph Diesel's compression-ignition combustion system has been around much longer than the vehicles it motivates today, yet it hasn't changed much in its basic operation. Each piston comes up in turn and supercompresses a charge of air and fuel until it combusts. Yet the latest state-of-the art technologies, such as high-pressure common-rail direct fuel injection, advanced materials, highly precise engine controls, turbocharging, and supercleansing exhaust after-treatment systems, have made modern diesels cleaner and more powerful, fuel-efficient, and refined than ever. And because all three U.S. heavy-duty pickup-truck makers offer new clean diesels for 2010-2011, now is a good time to take a closer look at each.

RAM 6.7-LITER CUMMINS I-6

Some say the Cummins diesel reputation alone is reason enough to want its latest industrial-strength turbodiesel six. Others might opt for it because it's the only one available with a choice of six-speed manual or six-speed automatic transmission. And many appreciate that it's the only one that meets ultra-tough 2010½ emissions standards without diesel emissions fluid (DEF).

On the other hand, the latest Cummins inline-six diesel, available in 2011 Ram 2500 HD and 3500 HD pickups, trails the new GM and Ford diesel V-8s in peak power and torque by substantial margins—350 horsepower versus 397 and 400, respectively, and 650 pound-feet versus 765 and 800. Still, the diesel Ram 3500 dualie with automatic transmission and 4.10:1 rear axle offers a plenty hefty maximum Tow Package GCWR of 25,400 pounds, maximum towing capability of 17,600 pounds, and a max payload of 5150 pounds.



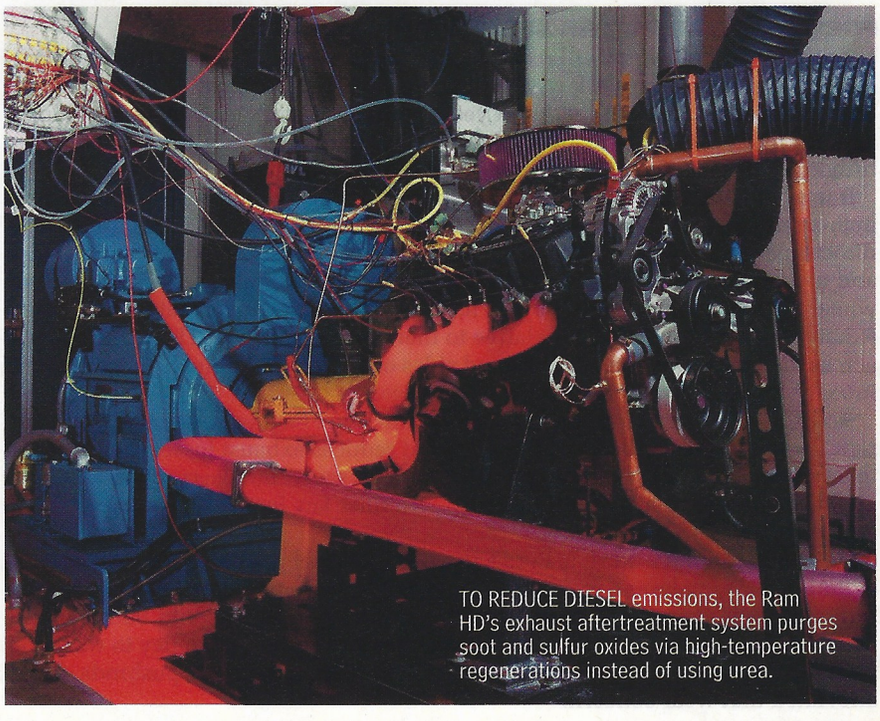
Chrysler Engine and Electric Propulsion Engineering Vice President Bob Lee contends that the Cummins' output deficiencies will go unnoticed by most. "You'll find the performance of our trucks is quite comparable," he says. "It is advantageous to have bigger numbers for advertising, but if you look at what these trucks can do, we're all in the same neighborhood. If there are differences, it's a small portion of the market that may actually find them. And we can deal with torque pretty easily with gear ratios."

Cummins' turbocharger uses a sliding variable-nozzle device with integrated electronics that control it. Lee explains, "We use that variable nozzle as an effective integrated exhaust brake." Its side-mount location is also unique compared with the usual valley of a V-8, where, he continues, "things are hot and congested." Other advantages include its 350,000-mile overhaul interval

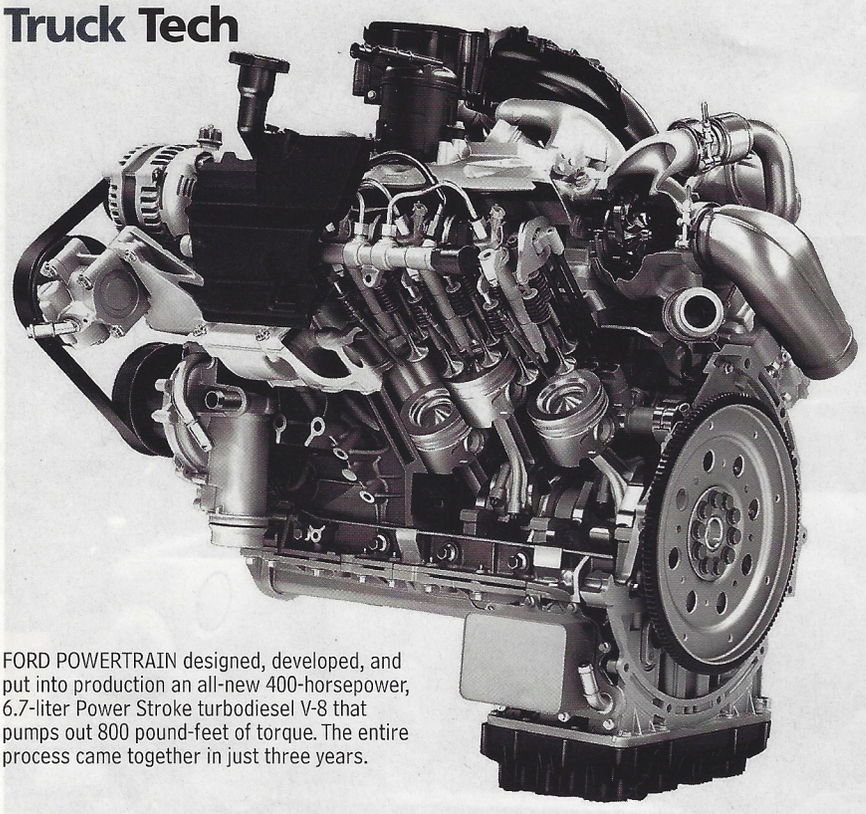
and its 5-year/100,000-mile warranty, both direct results of the Cummins' long history as an anvil-tough industrial engine.

The Ram HD's biggest bragging point, however, is that its exhaust aftertreatment system uses a catalyst that collects and periodically purges NOx with regular high-temperature "regenerations" instead of using DEF (also known as urea). "Our de-NOx process is what [the other manufacturers] do with urea," Lee says. Particulate emissions (soot) and sulfur oxides also are burned off by regenerations as needed. The downside is that regenerations burn fuel to generate the necessary heat, which somewhat reduces the truck's fuel efficiency.

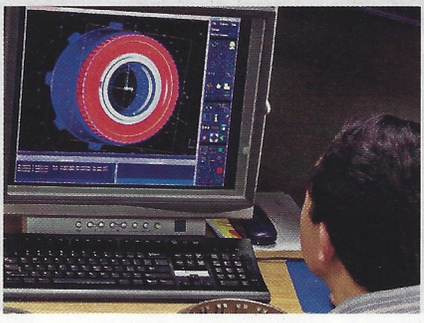
"We have to make the engine run in a very inefficient way to generate those high temperatures for short periods of time to purge the accumulated material," Lee concedes.



TO REDUCE DIESEL emissions, the Ram HD's exhaust aftertreatment system purges soot and sulfur oxides via high-temperature regenerations instead of using urea.



FORD POWERTRAIN designed, developed, and put into production an all-new 400-horsepower, 6.7-liter Power Stroke turbodiesel V-8 that pumps out 800 pound-feet of torque. The entire process came together in just three years.



FORD 6.7-LITER POWER STROKE V-8

Longtime Ford followers will recall that Ford HD diesels were supplied by Navistar until quality issues a few years back drove Ford to sever the relationship. Then, amazingly, in just three short years, Ford Powertrain designed, developed, and put into production its own all-new 400-horsepower, 6.7-liter Power Stroke turbodiesel V-8. It also pumps out a stunning 800 pound-feet of torque.

It uses aluminum cylinder heads with dual water jackets for better cooling; a high-strength, lightweight, compacted-graphite iron block; a new higher-pressure, direct-injection fuel system; an air-to-water intercooler (as opposed to air-to-air); and a compact single-sequential turbocharger with a double-sided compressor wheel to reduce turbo lag. But by far its most unique feature is that its intake and exhaust systems are reversed relative to their usual positions: The fuel lines run across the valve covers to the outboard sides of the heads, while the exhaust exits inboard to the centrally mounted turbocharger.

According to Ford North America powertrain Chief Engineer Adam Gryglak, this new design increases thermal efficiency and reduces exhaust losses. "We wanted to be among the leaders in power and torque," he says, "but we really focused our attention on best-in-class fuel economy." Another key focus was reducing noise, vibration, and harshness.

One more unique feature is Ford's use of individual pushrods for each of each cylinder's two intake and two exhaust valves. "Most manufacturers use one pushrod with a pivot arm and a single rocker arm on both intake and both exhaust valves," Gryglak explains. "Over time, that pivot arm has a tendency to wear and requires mechanical adjustment. By going to individual arms and pushrods, we've alleviated that wear concern."

SELECTIVE CATALYTIC REDUCTION

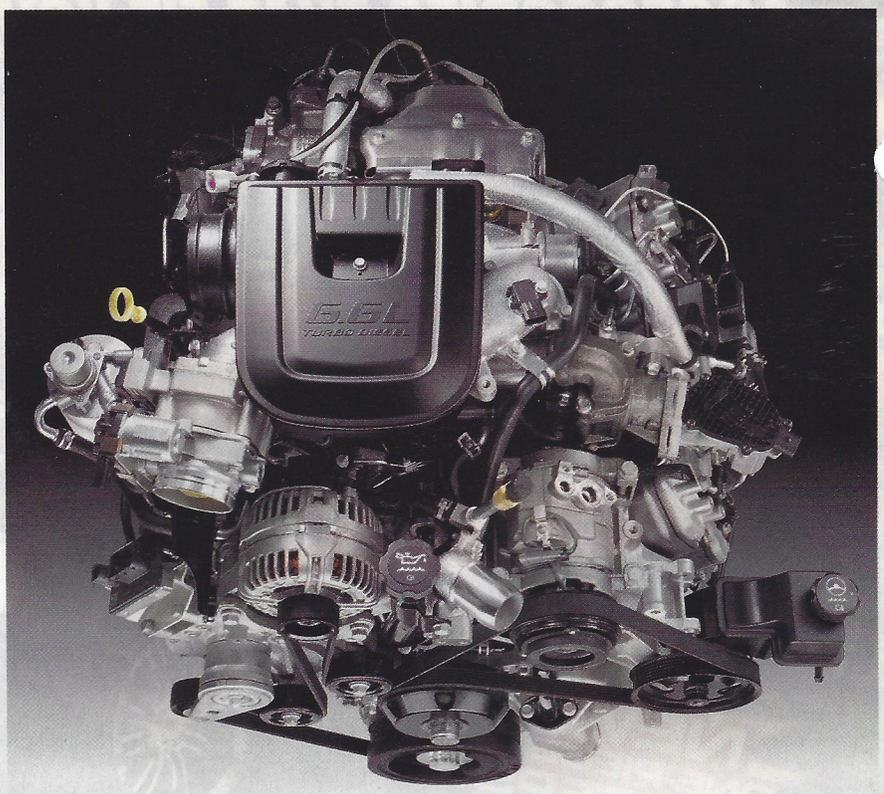
The challenge for automotive diesels under today's federal emissions standards is that they must be as squeaky clean as their gasoline counterparts. But diesel fuel is different—and compression-ignited diesel combustion very different—from spark-ignited gasoline combustion. The result is a different mix of emissions, including higher levels of nitrous oxides (NOx) and tiny particles of unburned carbon, aka soot.

Ford's new Power Stroke diesel V-8 meets 2010½'s much tougher emissions requirements by first reducing NOx production through more efficient combustion, then subjecting the exhaust to a three-step cleansing process. (GM's system is similar.)

STEP ONE: Cleaning and Heating—First comes the Diesel Oxidation Catalyst (DOC), which converts and oxidizes hydrocarbons into water and carbon dioxide (CO_2) at about 250 degrees Celsius while adding heat that increases efficiency of the downstream subsystems.

STEP TWO: Knocking Out NOx—Next comes the Selective Catalytic Reduction (SCR) chamber, where catalysts collect excess NOx. When this chamber is full and needs to be purged, DEF (an aqueous solution of about 67.5-percent water and 32.5-percent urea), is released into it, where it splits into ammonia and CO_2. These molecules are atomized and vaporized, then enter a corkscrew-like mixer that evenly distributes the ammonia before it passes through a catalyzed substrate that chemically combines and converts the collected NOx and ammonia into nitrogen and water at 200-500 degrees Celsius. (Ford says the on-board DEF reservoir will need to be refilled about every 7500 miles, depending on usage.)

STEP THREE: Scrubbing Away Soot—The final element is the Diesel Particulate Filter (DPF), which traps any remaining soot. The soot is periodically burned away by allowing the engine to momentarily run rich, which causes excess diesel fuel to combust in the exhaust system. This "regeneration" process creates temperatures in excess of 600 degrees Celsius.



GENERAL MOTORS 6.6-LITER DURAMAX V-8

GM's new-for-2011 Duramax turbodiesel V-8 took bragging rights briefly at its mid-2010 introduction with 397 horses and 765 pound-feet of pavement-wrinkling torque. Then Ford quickly countered with a software upgrade that boosted its new Power Stroke's rated output to the aforementioned 400 and 800. Like Ford, GM claims segment-best fuel economy, but the EPA doesn't rate the fuel economy of trucks with a GVWR over 6500 pounds.

While this new engine is an evolution of the Isuzu-designed original Duramax launched in 2001, since 2007 it has been a completely GM Powertrain-designed and developed unit, says Chief Engineer Gary Arvan. "Building on the previous Duramax is important in this market," he says. "We want a product that is proven, but we've applied a lot of new technology to make sure we can lead in most areas."

Among its new-tech features are faster, more accurate piezo injectors; a new quicker, more capable engine computer; and exhaust braking that uses the turbocharger's variable-vane (versus Ford's and Chrysler's variable-nozzle) technology to restrict exhaust flow when the throttle is closed, which creates substantial "negative torque" that slows the rig and saves the service brakes on extended downhill grades, for example.

"The piezo injectors deliver more accurate fueling and the ability to do more fueling events per combustion event," Arvan explains. "Part of that is a new dual-pilot strategy—two small squirts before the main power-delivery fuel to control noise and emissions, which are critical to achieving the best balance of performance, noise, fuel economy, and emissions."

Like Ford, GM has adapted selective catalyst reduction technology that uses DEF to control NOx emissions to 2010 emissions standards. But GM's system has two NOx sensors that provide readings up- and downstream of the catalyst "to allow us to optimize the urea injection," Arvan says. "The goal is to maximize the system's capability for the best urea economy possible. Having control of the system allows us to extend the engine's power capability as well control noise, fuel economy, and emissions."

A ninth (lower-pressure) injector injects fuel into the exhaust pipe, closer to the catalyst, to create the heat needed to burn off (regenerate) soot from the diesel particulate filter. "The advantage," he says, "is that we virtually eliminate dilution of the oil with fuel, which has been an issue in trucks with DPFs and is extremely important with B20 biodiesel fuel." GM's system also uses an exhaust gas recirculation bypass to add heat for selective catalytic reduction optimization, a low-backpressure cordierite ceramic DPF substrate and coalescer-type filtration to purge water from the fuel, also important for B20 capability.

Given the prospect of ever-tightening emissions standards that will continue to increase the cost of compliance—if not make it virtually impossible—some might fear these hard-working diesels may one day be legislated into extinction. Not Gryglak, who was Ford's diesel chief engineer before his recent promotion.

"I grew up as a gas engine guy," he says, "but I've spent the last five years in diesel. As I've watched diesel technology evolve, I continue to see a lot of opportunity. Diesels still have a large future in North America, especially in trucks." ***TT***

THE DURAMAX V-8's new features include exhaust braking technology that protects the service brakes on lengthy downhill grades.