Engine-Cylinder Deactivation Saves Fuel

By Jeff Youngs, February 24, 2012
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If an 8-cylinder car gets 20 mpg on the highway, what would happen if half of its cylinders were shut down? How about transforming a 6-cylinder engine into a 3-cylinder?

That's the simple idea behind cylinder deactivation. When the engine's full complement of cylinders is needed-while accelerating, trudging uphill, hauling a trailer-all of them operate normally. But when the car or truck is cruising, with only a light load, shutting down several of the cylinders is sure to increase fuel economy.

Not that the difference is enormous. Eliminating half the cylinders certainly doesn't double gas mileage, or anything close. Still, this step improves it enough to make quite a difference in overall running cost, as gasoline prices reach ever-higher levels.

GM paved the way_and lost its way_with innovative V8-6-4

Unfortunately, cylinder deactivation still carries a bit of stigma among some older drivers with long memories, and it stems from General Motors. At the time of the second national fuel crisis, in 1979, GM decided to manufacture an engine dubbed the V8-6-4. As its name suggests, this was essentially a V-8 engine, like many others in the GM lineup. Part of the time, though, either 2 or 4 of its cylinders could shut down, leaving either 4 or 6 in operation.

Developed by the Eaton Corporation, the innovative variable-displacement (also called "modular-displacement") engine was standard in all 1981 Cadillacs except for the Seville bustleback sedan (which could have it as an option). Depending on driving conditions, the V8-6-4 would run on 4, 6, or 8 cylinders, switching from one mode to the other and back again as needed.

The basic principle was not new. Experiments with variable displacement had been undertaken during World War II. In GM's version, a microprocessor determined which cylinders could be dispensed with at a given moment. Then, the microprocessor signaled a solenoid-actuated blocker plate, which shifted position to permit each unwanted cylinder's valve rocker arms to pivot at a different point than usual. Therefore, rather than operate normally, certain cylinders' intake and exhaust valves would remain closed. Valve lifters and their related pushrods moved up and down within the engine as usual, but those unneeded valve pairs remained idle.

While running on 4 cylinders, displacement reverted to all 8 as soon as the driver stepped on the gas pedal to pass or merge. That response was meant to assure drivers who wondered whether a 4-cylinder Cadillac would be sufficient. Not that they could expect vigorous response. Despite displacing 6.0 liters with all 8 cylinders in action, Cadillac's engine produced only 140 hp. This was still the age of reduced-output engines, which had begun during the 1970s.

Cadillac advised customers that any "perceived sensation" during a displacement change would be "slight," because no actual shifting was involved. Push a button, and an MPG Sentinel showed how many cylinders were operating. Push again, and the display showed instant miles-per-gallon.

The innovative new engine was hailed as a dramatic, if partial, solution to the fuel economy dilemma. Cadillac claimed gas-mileage improvement as high as 30 percent for highway driving.

Trouble brewing with V8-6-4

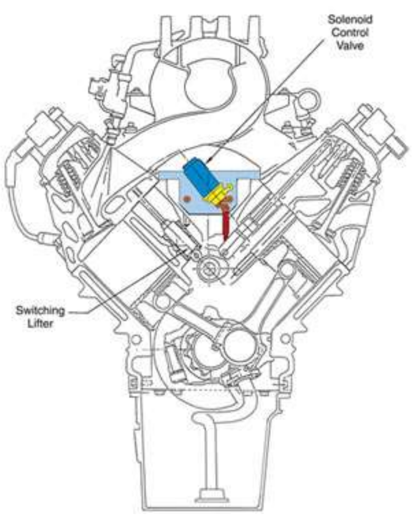
In practice, some nasty problems developed. Expanded self-diagnostics displayed 45 separate function codes that could assist a mechanic with investigation into any trouble that developed. And they did. The V8-6-4 engine was undeniably imaginative, but also complex. Computer control was a new concept, slow to react and not yet sufficiently developed to handle a task of this nature with suitable reliability. Instead, the modular displacement burdened many owners with incessant troubles, many of which were related to the somewhat primitive fuel-injection system. Rather than cut off fuel to the unused cylinders, the engine's injectors continued to keep them supplied, causing gasoline to accumulate.

Fleetwood limousines stuck with the V8-6-4 through 1984, but for other Cadillac models, it was replaced in 1982 by a new, conventional HT-4100 V-8. Cadillac had other ideas to boost fuel economy in 1982, including the debut of the 4-cylinder Cimarron. Some of the troublesome V8-6-4 engines were later converted into conventional V-8s.

Mercedes-Benz revives deactivation concept

Full-size Mercedes-Benz models sold in Europe in 1999 had something new: an Active Cylinder Control system that deactivated half the cylinders in the V-8 or V-12 engine. Mercedes' system used twin arms to actuate each valve, controlled by a computer. The pairs of arms could either be locked together or kept apart, to keep the valve operating normally or cause it to remain closed.

By this time, fuel-injection systems were far more sophisticated than in the era of GM's V8-6-4. Computer control also had made long strides. Even though fuel economy was not a major issue as the 21st century dawned, large engines appeared to be likely candidates for periodic deactivation.



GM: Displacement on Demand

More than two decades after the V8-6-4 debacle, GM was back with a far more sophisticated and dependable form of cylinder deactivation. First installed on the 2005 Chevrolet TrailBlazer and GMC Envoy SUVs with a 5.3-liter V-8 engine, Displacement on Demand (DoD) could cut off half the cylinders when the vehicle was under light load conditions, and restore them when the driver pushed on the gas pedal to accelerate, or the need for additional power was detected.

Displacement on Demand shut down every other cylinder in the engine's firing order. Special collapsible valve lifters were installed in four specific cylinders. These De-ac lifters had a spring-loaded locking pin actuated by oil pressure. Solenoids could increase the oil pressure, dislodging the pins for the affected valves and causing the top of each De-ac lifter to collapse-no longer contacting its pushrod. When more power was needed, oil pressure was removed and the lifters locked back into their full-length configuration.

GM claimed an eight-percent boost in fuel economy for the DoD-equipped SUVs. Displacement on Demand soon went into selected GM V-6 engines, in such models as the Pontiac G6.

Chrysler reintroduces Hemi V-8, with Multi-Displacement System
When Chrysler introduced its modern-day Hemi V-8 for the 2005 model year, concerns over fuel economy were beginning to increase. Chrysler had a solution, in the form of a Multi-Displacement System-cylinder deactivation under another name-for the 5.7-liter engine. Hemi power was available in the new-for-2005 Chrysler 300C and Dodge Magnum, as well as Dodge Ram pickups and Durango SUVs. Multi-Displacement Hemis also could slip into the Jeep Grand Cherokee and Commander, and the 2006 Dodge Charger.

Like other variable-displacement engines, Chrysler's system was designed so the car or truck started off with all 8 cylinders functioning. Above 18 mph or so, if the engine was cruising lightly at moderate rpm, half the cylinders could shut down until they were needed again to accelerate or climb a hill-whenever the load increased.

Special lifters were forced by oil pressure to collapse. As a result, the engine's camshaft was disengaged from the pushrods that acted upon selected valves in this overhead-valve design.Switching between 8- and 4-cylinder operation could take place in 40 milliseconds, according to Chrysler, and no fuel entered the unused cylinders. Chrysler claimed a fuel-economy improvement of 10 to 20 percent for Multi-Displacement in this Hemi V-8 engine.

Honda's Variable Cylinder Management
Starting with the 2005 Odyssey, Honda applied cylinder-deactivation-dubbed Variable Cylinder Management-technology to its 3.5-liter i-VTEC ("i" for "intelligent") V-6 engine. When high output was needed, the engine ran on all 6 cylinders. While cruising and under light load, one bank of 3 cylinders was idled. The unwanted cylinders were sealed shut for the duration,

minimizing internal pumping losses. As soon as full power was demanded, the additional valves went into action and their cylinders began to receive fuel.

In Honda's VCM V-6, the hydraulic circuit consists of two systems, each capable of providing the pressure needed to actuate the synchronizing piston that disables the unneeded valves. This is accomplished by separating the two tandem rocker arms that work with each valve, causing it to remain shut.

Honda's control system monitors throttle position, vehicle and engine speed, and automatic-transmission gear selection, to determine if the vehicle is cruising or decelerating. When idling those 3 cylinders, the system also alters ignition timing and turns the transmission's torque converter lock-up on and off, to suppress jolting during the transition between 6- and 3-cylinder operation.

Later, Accord and Pilot models could also get VCM. Honda claimed "a smooth, seamless switch between 3- and 6-cylinder modes that is nearly unnoticeable to the driver."

Except for Honda's V-6 engine, most cylinder deactivation is applied to domestically-built truck V-8 engines, though various GM V-6 engines also are benefitting from the technology. Still, the systems don't get nearly as much attention as some other methods of boosting fuel economy.

Start/Stop operation
Introduced mainly in hybrid cars, start/stop is another way of deactivating an engine under specific conditions. As a vehicle comes to a stop, its engine simply shuts off completely. Touch the gas pedal and it promptly fires up again, ready for action. Compared to cylinder deactivation, far more near-future vehicles are likely to apply this relatively elementary technology as a fuel-economy measure.