Honda's Six Cylinder Engine Technologies

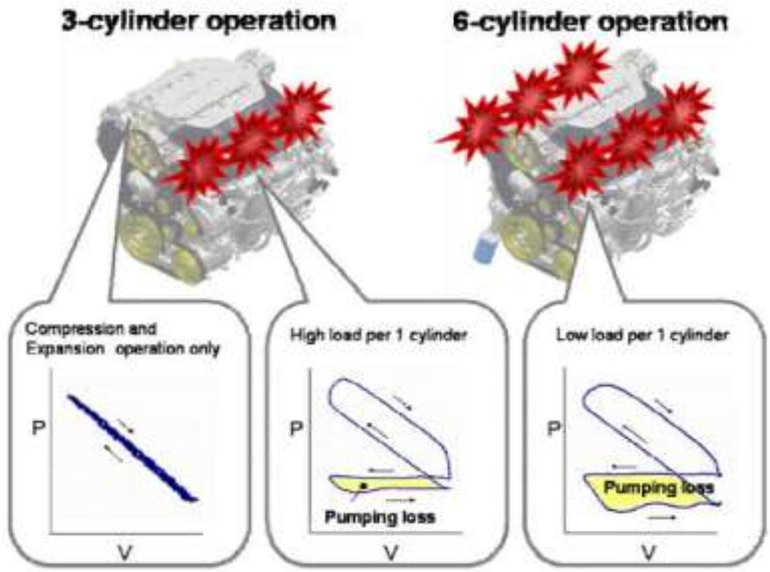
(some advantages and disadvantages)

The most recent 2015 Honda engine on Accord has the following specification: 3.5L SOHC 60^{o} V-6, 10.5 CR, with conventional MPFI using regular gasoline fuel. The GDI version of this is in Acura RLX has higher specific power and compression ratio of 11.5:1 (required premium fuel) but at the expense of about ~400 lbs more mass. Efficiency is the hallmark of this engine (~ 28 mpg (~8.4 L/100km)). These engines use Honda's i-VTEC (variable valve Timing and Lift Control) with *variable cylinder management* (VCM) (or cylinder deactivation), which allows engine operation in 3-cylinder mode under light load operation.

VTEC system provides engines with the ability of valve timing to be optimized for both low and high engine speeds (or rpm). There are two cam profiles, one for low-rpm stability and fuel efficiency and the other is designed to maximize high-rpm power output. The switching between the two is controlled by the *Electronic Control Unit (ECU)* which takes into account engine oil pressure, engine temperature, vehicle speed, engine speed and throttle position. In summary, the VTEC attempts to combine low-rpm fuel efficiency and stability with high-rpm performance.

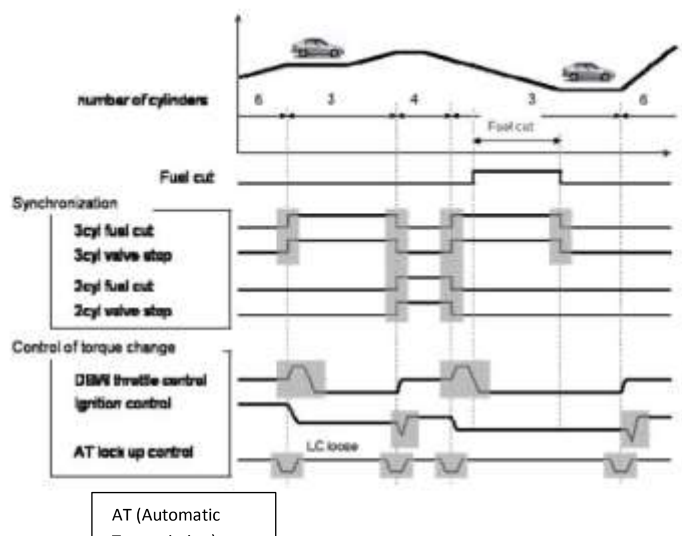
i-VTEC with 3-stage VCM. The basic idea is that the vehicle only requires a fraction of its power output at cruising speeds. The system electronically deactivates cylinders to reduce fuel consumption. This engine is able to run on 3, 4, or all 6 cylinders based on the power requirement. One receives V6 power when accelerating or climbing hills as well as the efficiency of a smaller engine when under cruising condition. During moderate speed cruising and at low engine loads, the system operates just one bank of three cylinder. For moderate acceleration, higher-speed cruising and mild hills, the engine operates on four cylinders. 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 changes 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 operations. Using the EPA's new 2008 approach, the Accord V6 Sedan delivers EPA-estimated fuel economy of 19/29 city/highway.

Generally speaking the fuel economy improvements are due to the following factors. 1) VCM eliminates "*pumping losses*" in the deactivated cylinders. By keeping the valves closed in the cylinder to stop fuel supply, it also prevents air in-and-out to that cylinder. This eliminates pumping loss—the air resistance incurred when the pistons pump intake air and exhaust gases through the cylinder—which is the largest source of resistance in engine operation at low loads. This is the primary reason why deactivating the cylinders contributes to improved fuel economy. 2) Reducing pumping losses in active cylinders. In 3-cylinder operation, the throttle is open wider. This makes inhalation of intake air easier for the active cylinders, reducing pumping losses for improved fuel economy. 3) Reduced losses from valve operation. Because the valves are deactivated, losses are largely reduced, allowing the engine to operate more efficiently. This contributes positively to improved fuel economy.



There is also the all-new 2016 Honda Pilot SUV with 3.5 L, Gasoline Direct Injection (GDI) i-VTEC, 11.5 CR, V6 engine with new two-stage VCM technology. For further fuel saving, this engine also includes a *stop-start feature*. This appears to be Honda's first non-hybrid application of this technology.

While the VCM is a clever technology to improve fuel consumption, deactivation of cylinders does come with some side effects. For one thing, engines operate more smoothly when the number of active cylinders increases. Hence there is an expectation for increase in NVH levels by going from 6 to 4 and to 3 active cylinder operations. To a certain extent this matter has been addressed through the use of active engine mount control system by Honda. Nevertheless, NVH levels with reduced number of active cylinders is higher. Moreover, transition between different modes of VCM is an important aspect of the engine calibration which makes matter even more complicated. Smooth transition is the key to a successful and long-term durability of such a system. The VCM may be repeatedly switching on and off during light throttle operation, at cruising speeds, on flat roads. Essentially, the engine is working much harder than it has to in normal driving conditions.



Pattern of VCM operation

Also, as a given cylinder is deactivated, its operating temperature is reduced. It is then increased when the cylinder is subsequently activated. Under certain operating condition, one can imagine that such comparatively larger temperature swings could lead to *enhanced in-cylinder deposit formations*. The components that are more vulnerable are spark plugs and valves. As for the spark plug fouling, this may lead to poor ignition or even misfire situation. Additionally, as temperature and pressure are reduced in deactivated cylinder it is conceivable that engine oil consumption may be different than normal all-cylinder operating condition. Lastly, lowered temperature due to deactivated cylinder may affect the catalyst temperature leading to possible negative impacts on its optimum operation.

However, such issues are normal every time one considers application of a new technology. I am confident that in time and with Honda's creative and innovative engineers the impacts of such issues will be substantially reduced to a point that is not of consumer concern during the useful life of the engine operation.

Accord Powertrain Specifications

Feature	Accord L4	Accord V6
Engine Type	L4	V6
Engine Block/Cylinder Head	Aluminum-Alloy	Aluminum-Alloy
Displacement (cc)	2356	3471
Horsepower (SAE net)	185 @ 6400 rpm	278 @ 6200 rpm
	189 @ 6400 rpm (Sport)	
Torque (SAE net)	181 lb-ft @ 3900	252 lb-ft @ 4900 rpm
	182 @ 3900 rpm (Sport)	
Redline	6800 rpm	6800 rpm
Bore and Stroke	87 mm x 99.1 mm	89 mm x 93 mm
Compression Ratio	11.1:1	10.5:1 (AT) / 10.0:1 (MT)
Valve Train	16-Valve DOHC i-VTEC®	24-Valve SOHC i-VTEC®
Fuel Injection	Direct	Port
Required Fuel	Regular Unleaded	Regular Unleaded
Transmission	CVT	6AT
	6MT	6MT (Coupe only)

2016 Honda Accord

2016 Accord Anticipated EPA Fuel Economy Ratings

Accord 4-Cylinder	Trans	Anticipated EPA MPG[1] (city/highway/combined)	
		Sedan	Coupe
LX (Sedan); LX-S (Coupe)	6MT	23/34/27	23/34/27
	CVT	27/37/31	26/35/30
Sport (Sedan)	6MT	23/34/27	--
	CVT	26/35/30	--
EX	6MT	23/34/27	23/34/27
	CVT	27/37/31	26/35/30
EX-L	CVT	27/37/31	26/35/30
EX-L w/Navi	CVT	27/37/31	26/35/30
EX-L	6MT	--	18/28/22
	6AT	21/34/26	21/32/25
EX-L Navi	6AT	21/34/26	21/32/25
Touring	6AT	21/34/26	21/32/25

[1] Anticipated 2016 EPA mileage ratings. Use for comparison purposes only. Your mileage will vary depending on how you drive and maintain your vehicle, driving conditions and other factors.