Cylinder Deactivation (Dynamic Fuel Management) System Description

Dynamic Fuel Management (DFM) is recognized as active fuel management technology with the additional ability to deactivate any combination of cylinder valves for an internal combustion engine. This technology combines millisecond-accurate torque control with cylinder deactivation to optimize fuel consumption of spark ignited engines. The control of every cylinder event optimizes engine operation such that peak efficiency is obtained throughout the range of engine operation. DFM extends cylinder deactivation to all cylinders, which allows for a large variety of firing sequences. DFM can have rotating cylinder deactivation patterns as well as fixed patterns. For rotating patterns, which cylinders are being deactivated can change with each subsequent engine cycle. Transitions between firing sequences is done in a continuous fashion, making the transitions seamless and transparent to the vehicle operator.

The fuel injectors will be turned off during cylinder deactivation to prevent fuel buildup in the cylinder. To help prevent spark plug fouling, the ignition system secondary voltage or spark is still present across the spark plug electrodes on the deactivated cylinders. If all enabling conditions are met and maintained for cylinder deactivation operation, the ECM calibrations will limit an individual cylinder's deactivation to a predetermine number of continuous cycles, then reactivate that cylinder (normal operation) for a predetermined number of engine cycles before allowing deactivation again. The engine will operate normally on all cylinders during engine starting, engine idling, and medium to heavy throttle applications.

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Valve Lifter Oil Solenoid Valve

The cylinder deactivation system uses electrically operated electro-hydraulic actuator devices called the valve lifter oil solenoid valves. The valve lifter oil solenoid valves are bolted at each cylinder in the engine block valley, below the intake manifold assembly. The valve lifter oil solenoid valves are energized with peak-hold current drivers for faster response with lower variation. Each solenoid controls the application of engine oil pressure to the intake and exhaust valve lifters on the cylinders selected to deactivate. Engine oil pressure is routed to internal oil passages on the cylinder block.

When all enabling conditions are met for cylinder deactivation, the ECM will allow current to flow through the solenoid windings. With the coil windings energized, the solenoid valve opens, redirecting engine oil pressure through the valve lifter oil solenoid valves into separate vertical passages in the engine lifter valley. Each cylinder has two vertical passages connected to the valve lifter bores. When vehicle operating conditions require cylinder activation, the ECM will turn off the control circuits for the solenoids, allowing the solenoid valves to close. With the solenoid valves closed, engine oil pressure in the control ports is exhausted. Any air that is trapped in the system is purged by turning the solenoid on periodically with very short purge pulses.

During service, use extreme care in keeping the valve lifter oil solenoid valve free of any contamination or foreign material.

Valve Lifter

Cylinder deactivation is accomplished by not allowing the intake and exhaust valves to open on the selected cylinders by using special valve lifters. The deactivation lifters contain spring loaded locking pins that connect the internal pin housing of the lifter to the outer housing.

The pin housing contains the lifter plunger and pushrod seat which interfaces with the pushrod. The outer housing contacts the camshaft lobe through a roller. When cylinders are active, the locking pins are pushed outward by spring force, locking the pin housing and outer housing together causing the lifter to function as a normal lifter. When driving conditions have been met for cylinder deactivation, the locking pins on the selected cylinder lifters are pushed inward with engine oil pressure directed to passages in the engine block valley. When the lifter pin housing is unlocked from the outer housing, the pin housing will remain stationary, while the outer housing

will move with the profile of the camshaft lobe, which results in the valve remaining closed. The valve lifter oil solenoid valve controls both the intake and exhaust valves for each deactivating cylinder. There are 2 distinct oil passages going to each cylinder deactivation lifter bore, one for the hydraulic lash-adjusting feature of the lifter, and one for controlling the locking pins used for cylinder deactivation.

Although both intake and exhaust valve lifters are controlled by the same solenoid, the intake and exhaust valves do not become deactivated at the same time. Cylinder deactivation is timed so that the cylinder is on an exhaust event. The intake valve is instantly deactivated while the exhaust valve is still open. During an exhaust event, the exhaust cam lobe is pushing the valve lifter upwards to open the exhaust valve against the force of the valve spring. The force exerted by the valve spring is acting on the side of the lifter locking pins, preventing them from moving until the exhaust valve has closed. When the exhaust valve lifter reaches the base circle of the camshaft lobe, the valve spring force is reduced, allowing the locking pins to move, deactivating the exhaust valve. DFM differs in charge trapping strategy with a low pressure combustion charge trapped in deactivated cylinders, requiring deactivating and activating the intake valve before the exhaust valve.

Conditions for DFM Operation

The conditions listed below determine when cylinder deactivation is enabled.

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- Engine coolant temperature is between 40−126°C (100−264°F)
- Engine has been running for greater than 20 s
- Engine oil pressure is between 187−585 kPa (27−84 psi)
- Engine oil temperature is between 20−128°C (68−262°F)
- Engine speed is between 700 and 2675 rpm
- Ignition voltage is greater than 11 V
- Transmission is not in, neutral, park, first, second, or reverse gear
- Vehicle is not in heater performance mode
- Vehicle is not in tip in bump acceleration mode
- Vehicle is not in oil aeration mode
- Vehicle is not in low gear ranges
- Vehicle speed is greater than 13 kph (8 mph)

The conditions listed below may be reasons for inhibiting deactivation:

- Accelerator pedal out of range or rate of pedal application too fast
- Catalytic converter over temperature protection is active
- Cylinder deactivation solenoid driver circuit faults
- Decel fuel cutoff is active
- Enabling criteria not met
- Engine oil pressure and temperature out of range
- Engine speed out of range
- Maximum cylinder deactivation time exceeded
- Piston protection is active, knock detected
- Reduced engine power is active
- Torque management is active
- Transmission gear incorrect or shift in progress
- Vehicle speed out of range