Why Direct Injection Engines Develop Carbon Deposits

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Andrew Markel, EDITOR, UNDERHOOD SERVICE MAGAZINE
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Direct injection in its current form has been around since 1997. During the next 10 years, Volkswagen, BMW, Mercedes Benz and many others introduced engines with direct injection. Today, almost all new engines have direct injection.
When the early direct-injection engines hit the three-year or 30,000-mile mark, some developed driveablity problems due to carbon build-up on the necks of the intake valves. Typical symptoms were misfire codes, stumbling and suspicious fuel trim numbers.
Carbon deposits cause the air to tumble into the combustion chamber, and this turbulence causes the fuel and air mixture to be unevenly distributed. When ignited, the flame front can be erratic, leave unburned fuel and create hot spots in the combustion chamber.

Why are direct injection engines prone to carbon deposits?

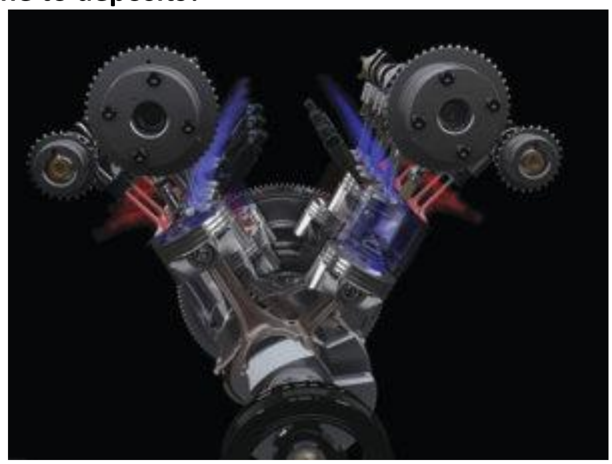
In the late '90s and early 2000s, TSBs related to carbon deposits on the valves were few and far between. There are three reasons why direct injection engines are more prone to carbon deposits. One reason is unique to direct injection, and the remaining two are problems for port fuel injection engines too, but are made worse by direct injection.

The main reason is that fuel and added detergents are not hitting the back of the intake valves. By injecting the fuel directly into the cylinder instead of at the back of the valve, the gasoline and detergents can't clean the valve and port.
Second, leaner mixtures and higher combustion pressures can make the problem worse over time. A direct fuel injection motor produces more energy from a given amount of fuel and air than a port fuel injection engine. Today's engines operate on a ragged edge between optimal efficiency and a misfire. There is not much room for error like hot spots in the combustion chamber or a worn spark plug.
When a hot spot or sub-optimal flame front is created due to turbulent air, the amount of unburned fuel in the combustion chamber increases. When the valve opens during the intake stroke, it might come in contact with these byproducts, and unlike the exhaust valve, the gases passing by are not hot enough to burn it off.
Third, the intake valve goes into the combustion chamber, regardless if it is port fuel injected or direct injected. When it does, for that small period of time, it is exposed to combustion

byproducts that can stick to the neck of the valve. If the last combustion cycle was less than optimal, the intake valve is exposed.

Some direct injection vehicles with variable valve timing can expose the valve to combustion byproducts as the valves adjust, which creates a scavenging effect to either pull or leave behind a small amount of exhaust gases in the chamber to control NOX emissions. Also, some turbocharged direct injection engines will leave the intake and exhaust valves open at the same time in order to keep the turbo spinning to reduce lag.

Why are some direct injection engines more prone to deposits?



If you look up direct injection carbon deposit problems on the Internet, engines from BMW, Audi and VW always rank the highest. Engines from GM and Ford that have been on the road for at least four years hardly have a carbon deposit complaint. What's the deal?

Some direct injection engines have bad timing. The modern engine typically has variable valve timing and even cylinder deactivation. The engine management system can control when, how long and, in some cases, how deep the valve goes into the combustion chamber. If an intake valve is dropping into a combustion chamber with combustion byproducts or unburned fuel, the valve might be exposed to the precursors that cause carbon build-up.

Some have blamed the positive crankcase ventilation (PCV) systems for leaving an oily film on the intake valve that is then baked into carbon. Some blame the valve overlap during the intake stroke that eliminates the need for an EGR valve.

The Fix

There are several fixes available to solve carbon build-up problems.

The first is preventive maintenance. Scheduled oil changes can keep the camshaft actuators working in optimal condition to control the exposure of the intake valves. Spark plug replacement can reduce the amount of unburned fuel in the combustion chamber that can stick to a valve. Fuel injector cleaning can help injectors maintain the correct spray geometry.

But the number one method for preventing a carbon build-up problem is updating the engine management software. New software can reduce carbon deposits by reducing the exposure of the valves to conditions that cause carbon build-up by adjusting valve and spark timing.

Don't assume that you will find a TSB saying that a reflash of the ECM will correct a carbon build-up problem because most of the updates will be contained in normal housekeeping that may never say anything about a problem. You may even have to check the OEM's website to see if the vehicle has the latest version of the software.