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Present and Future Vehicle Powertrains - Part Two

This *Counter Point* edition continues our discussion of present and future vehicle powertrain technology.

In the last *Counter Point* (Winter 2007), we introduced you to hybrid and flex fuel vehicle powertrain systems. We're continuing our discussion of present and future vehicle powertrains in this issue with clean diesel, biodiesel, compressed natural gas, propane and fuel cell vehicles.

Clean Diesel Engines

Hybrids are most economical in traffic. In other words, they are at their best in the worst driving conditions. The hybrid's gasoline engine does most of the work at highway speeds. Because the engine in most current hybrids is relatively small, it works hard, and real highway mileage can be less than advertised. A possible solution to this problem comes in the form of clean diesel power.

Since October 15, 2006, nearly all highway diesel fuel sold is ultra-low sulfur diesel (ULSD) fuel. This new fuel must contain no more than 15 parts per million (ppm) of sulfur, from a previous level of 500 ppm. This 97% reduction in sulfur helps reduce emissions from both new and existing diesel vehicles. ULSD, or clean diesel, enables the use of new emissions control technology – such as particulate filters and catalytic converters – which dramatically reduce emissions from new diesel vehicles.

Bluetec is the Mercedes-Benz name for its clean diesel technology. An oxidation catalytic converter and particulate filter are combined with an NO_x trap and selective catalytic reduction (SCR) converter to reduce the nitrogen oxide and particulate emissions that have been the bane of diesel engines. Because of the catalytic converters and filters, ULSD fuel must be used. This technology meets the most stringent standards now in place. Bluetec diesel technology is currently certified in 45 states, but it will be further developed to meet the California Air Resources Board (CARB) standards, as well as in states that adhere to California emissions standards.

Other vehicle manufacturers are also working on their versions of clean diesel technology. If these vehicles gain acceptance with the motoring public, look for diesels to represent a larger percentage of the vehicle population. Clean diesel technology is a refinement of something most technicians are already familiar with: the diesel engine. From a service standpoint, your most valuable tools for clean diesel vehicle service will be information and training.

Biodiesel Fuel

Like E-85, biodiesel is a fuel that's made from a renewable resource. In this country it's soy beans. There are plenty of farmers who would be more than happy to grow more soy beans, reducing our dependence on oil, and specifically imported oil.

After they are harvested, the soy beans are crushed to release the soy oil, which is then shipped to a refinery. The soy oil is placed in temperature-controlled stainless-steel tanks. From there it goes through a transesterification reaction process. The soy oil, which has a high content of triglycerides, is mixed with a catalyst — methanol and pot ash (potassium hydroxide). In three to four hours the mixture yields biodiesel fuel floating on the top and crude glycerin at the bottom.

The glycerin is removed and the biodiesel fuel is ready to be processed further. The next step is to remove any methanol. After that, the biodiesel fuel is filtered twice more to remove any remaining traces of water, methanol, glycerin and triglycerides. All through the process, the liquid must be kept at a precise temperature and each step must be carefully timed. Biodiesel can be mixed with regular diesel fuel to produce a blend. For example, B-20 is 20% biodiesel and 80% conventional diesel.

Vehicle manufacturers have been cautious in their support of biodiesel use in their vehicles. Some manufacturers support only certain types and blends in pre-2007 diesel engines. Their warranties won't cover damage caused by any bad fuel, including biodiesel. If bad fuel clogs a filter prematurely, that is not a defect in materials or workmanship. Biodiesel clears dirt and sludge from fuel tanks and may require extra filter changes.

If a customer wishes to experiment with biodiesel fuel in his vehicle, make sure he is aware that he may be on his own if it results in any engine damage. Perhaps most importantly, any alternative fuel (like biodiesel) should come

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Fine Tuning

Fine Tuning questions are answered by Mark Hicks, Technical Services Manager. Please send your questions to: Mark Hicks c/o ***Wells Manufacturing, L.P., P.O. Box 70, Fond du Lac, WI 54936-0070*** *or e-mail him at* ***technical@wellsmfgcorp.com.*** *We'll send you a very nice Wells golf shirt if your question is published. So please include your shirt size with your question.*

Q: I am working on a 2002 Volkswagen Beetle GLS with a 1.9 L diesel engine. It was towed into the shop with a no-start condition. I checked the codes and found the number 3 injector was defective. I ended up replacing all of the injectors. The engine then started and ran fine. However, after a few minutes of running the glow plug light started flashing. I contacted a friend at the dealership and he told me that the glow plug relay is inside the PCM. Replacing the PCM would be an expensive guess. I have also heard this vehicle has problems with the wiring harness. What should I do next?

Dave Beecher
Los Angeles, CA

A: Yes, the wiring harness needs a thorough check due to a reduction in wire size; there are many problems with the diesel wiring. If the glow plug light stays on steady, it could mean a glow plug or wiring problem. But when the glow plug light flashes, it usually *is not* an indication of a glow plug problem.

For the past 15 years, I have worked closely with several very good and caring engineers. But the logic involved in this system is a challenge for me to understand. For safety reasons, engine speed is regulated when the brakes are applied. If the brakes are applied and the accelerator is simultaneously depressed, engine RPM will remain at idle. This means a power brake test will not work on this vehicle.

To accomplish this safety feature, the PCM requires input signals from the brake and vacuum vent switches. If the brake light switch is incorrectly adjusted, it could result in an unnecessary engine RPM regulating action. This all makes perfect sense to me. But I can't explain why the glow plug light flashes if the brake light switch or brake light bulbs are defective. It's a real jungle out here.

Results: Dave replaced the burned out brake lights and the menacing mystery of the flashing glow plug light is solved.

In the previous *Counter Point* (Winter 2007), we had a code P0410 (secondary air system performance) on a 2001 Chevrolet Blazer equipped with a 4.3L VIN W engine. The air pump and fuse had been replaced, but the code continued to reappear.

To accelerate catalyst function, the secondary air injection system forces filtered air into the exhaust stream, primarily during the warm-up period. The operation begins when the PCM supplies a ground to a relay, which then supplies voltage to the air pump. The PCM also supplies a ground to the vacuum control solenoid, allowing engine vacuum to be applied to the air injection shutoff valve. When vacuum is applied to the air injection shutoff valve diaphragm, a valve opens to allow air to flow through the check valves and into the catalytic converters.

To pinpoint this problem, we have to look at what is left in the system that could still cause a restricted airflow. The vacuum hoses and the rest of the plumbing have already been checked. The pump turns on and flows air. That leaves two possibilities: either the shutoff valve is not opening, or the check valve is stuck or restricted.

To check the flow to the check valve, disconnect the hose right before the valve. Turn the air injection pump ON and apply vacuum to the shutoff valve if necessary. If forced air is not flowing out of the hose, the shut off valve diaphragm is defective. If it is flowing, the check valve is defective. In this case, the culprit happened to be the check valve.

If an air injection pump has failed, always check inside for water accumulation. If the water has a yellowish tint and smells like exhaust, the check valves also need replacement.

The first readers with the correct answer were:
Corey Padgett
Midas
Wheaton, IL

Red Yanez
Aggieland Automotive
College Station, TX

Diagnose The Problem Win A Shirt

A 2001 Honda Civic LX with a 1.7 L engine came into the shop this morning, and the customer's complaint was that the alternator was not charging. I opened the hood and found the alternator hanging loose because its lower mounting bolt had sheered off. I replaced the alternator mounting bracket bolts and tightened them to torque specifications.

I started the engine, and the charging system was putting out around 14.1 volts. I thought I had fixed the customer's problem. But as the engine temperature began to rise, the charging voltage also increased. After about five minutes of running, the charging system was putting out about 16.5 volts.

I have replaced the alternator and the battery. I also have checked all related wiring and connections, but I can't get the charging voltage to drop to a safe level. What else could be wrong and how do I check it?

Chuck Wright
Addison Tire
Edwardsburg, MI

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Quality Points

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own ignition coil. Reducing duty cycle reduces the excess heat generated by the coil. But due to coil location, amperage input and wire design, the age-old problem of heat deterioration persists. That's why Wells tests its coils to extremes they will never see on a well-maintained engine.

Test conditions include:
- Oven temperature 125° C/257° F.
- Spark gaps are adjusted to various gaps to increase or decrease secondary voltage. In an extreme test of coil durability, the spark gap is increased to two hundred-thousandths of an inch.
- Frequencies are adjusted to simulate various engine RPM.
- Current pulse time is adjusted to set the primary current charge time.
- Coils are run for 1,000 hours at varying frequencies, equating to more than 70,000 miles on the road.
- Data sheets are used to record coil performance over the duration of the test cycle.
- As many as 96 ignition coils are tested simultaneously.

A company's claims of product quality shouldn't be accepted on faith. By providing the preceding information, we are offering the proof to back our claims. To extend this further, we also provide a video tour on our website at www.wellsmfgcorp.com. Click on *Newsletter* along the top row or *Counter Point* in the *Technical* section on the left. Download this version, then click on the camera in the *Quality Points* section to view.

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Present and Future Vehicle Powertrains

from a reputable source. Experimentation with cooking oils and other low cost "grease diesel" or free fuel solutions may be interesting, but the customer must be made aware that he will be fully responsible for the outcome, good or bad.

Compressed Natural Gas

Natural gas is one of the most common forms of energy used today. Compressed natural gas (CNG) is used in thousands of vehicles worldwide. Overall, the benefits of using CNG include lower fuel costs, increased performance and reduced emissions. CNG generally costs 15-40% less than gasoline or diesel fuel. In conjunction with the increased performance, operators get a longer-lasting, lower-operating cost vehicle. Emissions reductions are significant for CNG fueled vehicles at approximately 90% for CO, 35-60% for NOx, and 50-75% for HC.

Two drawbacks exist for CNG vehicles: cost and fuel economy. An additional cost of $3,500 to $6,000 per vehicle is primarily due to the cost of equipping the vehicle with a fuel cylinder(s). Additionally, more frequent fueling of CNG vehicles is required due to CNG's lower energy content.

Servicing a CNG-powered vehicle will offer few challenges for a well-trained technician. CNG-powered vehicles operate much like gasoline-powered vehicles, since both rely on internal combustion engines. The plumbing is a bit different and certain precautions must be taken when working around the pressurized fuel cylinder.

Propane

Propane, or liquefied petroleum gas (LPG), has been in use as a transportation fuel since the 1940s. More than 190,000 propane-powered vehicles are in use in the United States today, and there are more than 9 million worldwide. Many vehicles that use this fuel are dual-use vehicles and can switch between gasoline or propane fuel.

The benefits of propane-fueled vehicles include reductions in operating costs and emissions. The cost of propane, depending on market factors, is usually comparable to gasoline. Depending upon vehicle calibration, propane offers reduced carbon monoxide and hydrocarbon emissions.

The primary drawbacks with propane-fueled vehicles when compared to gasoline-fueled vehicles are cost and reduced fuel economy. Overall, the cost of propane-fueled vehicles is $3,000 to $5,000 higher than gasoline-fueled vehicles. Additionally, propane-fueled vehicles get lower fuel economy when compared to gasoline-fueled vehicles.

Like CNG-powered vehicles, LPG-powered vehicles will offer few challenges for a well-trained technician. LPG-powered vehicles operate much like gasoline- and CNG-powered vehicles. Both rely on internal combustion engines, but the plumbing is a bit different and certain precautions must be taken during refueling, or any time it is necessary to work around pressurized propane storage tanks.

Fuel Cell Vehicles

Hydrogen would seem to be the perfect vehicle fuel source. The hydrogen atom is a key component of the water molecule, and we all know that a large percentage of the earth's surface is covered by water. Hydrogen also can be refined or extracted from other readily available natural resources.

Hydrogen is already in use as a fuel for specially modified internal combustion engines. If these engines end up being manufactured in larger numbers, they may provide a transitional phase between our current gasoline- and diesel-fueled vehicles and fuel cell-powered vehicles.

GM hydrogen fuel cell stack and related plumbing.

Page 1 and 3 photos: Wieck Media.

A fuel cell is an electrochemical energy conversion device that converts hydrogen gas and oxygen into water and heat, and produces electricity in the process. In the kind of hydrogen fuel cell that will probably be used in production vehicles, a proton exchange membrane fuel cell (PEMFC) has an anode and a cathode separated by a proton exchange membrane. A catalyst, usually made of platinum powder, is placed between the membrane and the cathode. The anode is the negative post of the fuel cell and conducts electrons that are freed from the hydrogen molecules. It also disperses the hydrogen gas evenly over the surface of the catalyst.

The proton exchange membrane (PEM) is a special material that conducts only positively charged ions and holds back the electrons. The catalyst is a specially treated material that facilitates the reaction of oxygen and hydrogen. The cathode is the positive post of the fuel cell, and it distributes oxygen to the etched surface of the catalyst. It also conducts electrons back from the external circuit to the catalyst, where they recombine with the oxygen and hydrogen ions to form water.

When the fuel cell is operating, hydrogen gas (H_2) under pressure is forced through the catalyst. The hydrogen molecules contact the catalyst and the hydrogen splits into two hydrogen ions and two electrons. The electrons bypass the membrane and go through an external circuit to create the electricity that powers the vehicle. On the cathode side, oxygen gas (O_2) is forced over and through the catalyst, where it forms into two oxygen atoms with a strong negative charge. The negative charge attracts the two hydrogen ions through the membrane, where they combine with an oxygen atom and two of the electrons from the external circuit to form a water molecule (H_2O).

Each hydrogen fuel cell produces a very low voltage (.7 volt), so many fuel cells must be stacked together to get any real power from a hydrogen fuel cell powerplant. The stack of interconnected hydrogen fuel cells is called a fuel-cell stack. Electricity produced by the fuel stack is sent to a storage battery, which in turn provides electricity to the vehicle's electric drive motor or motors.

Several things must happen before hydrogen fuel cell vehicles will be ready for widespread use. Probably most important will be the establishment of a hydrogen delivery network. At this point, a relatively small number of refilling stations have been built and are ready to use. Most are in government or corporate hands and are not open to the general public. Second, further improvements in battery technology must be made. And lastly, the cost of producing hydrogen fuel cell vehicles must be reduced to the point where they can be priced competitively with conventionally-fueled vehicles.

Several start dates for fuel cell vehicle mass production have been suggested. It all depends on who you talk to, but it's probably safe to say that the date is at least five years in the future. Several of the other vehicle powertrain systems we've discussed are already in use, or will be shortly. Are you ready?

We'll do our part by devoting continuing ***Counter Point*** coverage to emerging vehicle technology, including in-depth discussion of the components that make these new systems work. Dissection of an E-85 flex fuel vehicle's fuel sensor is just one example of what will be coming your way.

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Quality Points

The Proof Is In...

VIDEO - HIGH SPEED CONNECTION

VIDEO - 56K/DIAL-UP

An ignition coil transforms available battery voltage into the higher voltage necessary to bridge a spark plug's electrode gap. This high voltage normally ranges from 12,000 to 20,000 volts, but can reach 40,000 volts. On early ignition systems, one coil was responsible for firing all of the engine's spark plugs. At high RPM on an eight-cylinder engine, this left very little time for the coil to recover between discharges for individual spark plugs.

This became an extremely adverse condition when secondary resistance increased. As the spark plug electrode gap increased, resistance also increased and a higher coil output voltage was required to bridge the plug gap. Heavy coil windings are placed in an oil-filled canister to act as a heat sink and dielectric insulator. Later designs did away with the oil and used heat-sinking epoxy to help dissipate the high temperatures. Even with these design features, excessive heat remains a primary cause of premature coil failure.

Today's coil designs have changed significantly since the oil-filled can days. However, their electromechanical properties remain the same. Most of today's ignition systems utilize a coil-on-plug (COP) design, eliminating RF interference-causing ignition wires. In addition, COP decreases the coil duty cycle because each spark plug has its

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