

# engine

technology international



# Third dimension

Are inroads in 3D printing set to revolutionize the mass-production of engine components?

June 2014



### CALIFORNIA DREAMIN'

There's much more to the new Ferrari California T V8 than just the twin-scroll turbocharger setup

### FORCE FED

With IC designs becoming smaller, the future of charging is safe... or is it?

### ORGANIC MATTER

Natural gas and alternative fuels are fast becoming a viable solution to realizing sustainable transportation

# Catalyst heating showcase

Real-world testing has shown that a new type of PCI high-power plug is able to improve engine stability at highly retarded timing settings, in the process far out-performing conventional plugs

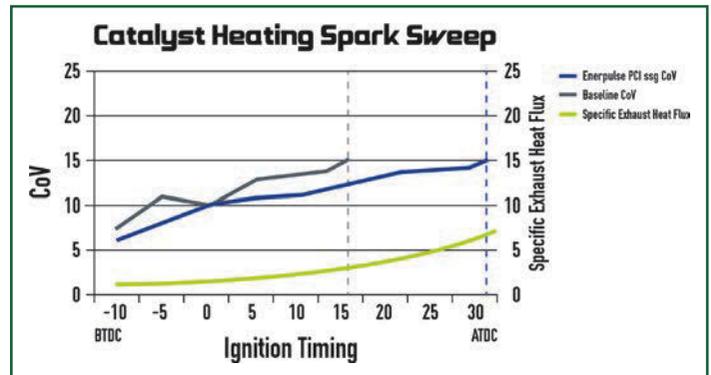
▶ A key element in meeting future tailpipe emissions regulations in a cost-effective way is to realize faster catalyst heating during the cold-start phase. Modern vehicular emission systems rely on catalytic converters to abate regulated tailpipe emissions. As such, the challenge for OEMs is to ensure that catalytic converters operate at full efficiency until they reach the light-off temperature level, which may take several minutes to achieve when the engine starts from a cold condition. The result of this is that such long periods of time are enough to contribute significantly to a vehicle's overall tailpipe emissions.

Extremely retarded ignition timing during a cold start can increase enthalpy (specific heat flux as a value of temperature, mass and velocity of the exhaust stream) to the catalytic converter, in the process shortening the time taken to achieve full abatement efficiency. Up until now, the technical challenge has been on overcoming issues relating to conventional spark plugs that do not have sufficient discharge power to reliably ignite the fuel charge during the engine power stroke. One ignition technology that has been shown to improve the limits of retarded ignition timing (and leaned mixture for low-load catalyst warming) is pulsed energy ignition. In controlled studies, this technology has consistently shown improved engine combustion stability at low load and idle conditions, which is synonymous with the cold-start phase of the drivecycle certification test. Furthermore, with controlled combustion bomb testing, pulsed energy ignition technology shows far shorter ignition and flame development periods, thus suggesting the ability to ignite more difficult combustion mixtures, such

as very lean mixtures or highly turbulent or static mixtures.

These findings prompted a controlled study to determine the potential improvement in combustion stability and emissions output during the low-load catalyst warming operation of a spark-ignition engine. The study examined combustion stability, emissions and exhaust heat flux behavior at varied ignition timing, revealing that pulsed energy ignition technology can increase exhaust heat flux for similar combustion stability criterion (less than 15% CoV of IMEP) with an added benefit of reduced unburned hydrocarbon emissions. Enerpulse PCI plugs couple an embedded capacitor directly to the center electrode, allowing the plugs to produce a 5MW electrical discharge at 150MHz that conditions the fuel charge during the spark event. This discharge forms a plasma field with very high ultraviolet photon energy around the spark gap. The plasma field extends into the combustion chamber and sensitizes a large portion of the fuel air mixture, thus greatly enhancing combustion during cold start.

An experimental single cylinder engine test explored the limits of ignition timing using Enerpulse PCI technology and found PCI plugs are capable of delivering targeted 15% CoV at dramatically retarded timing. The PCI plugs were able to reach 15% CoV at 32° ATDC ignition timing, while the OEM spark plug exceeded 15% CoV at 16° ATDC. The more retarded the timing, while maintaining the target CoV, will result in more exhaust heat flux, thereby reducing emissions during the EPA's FTP75 drivecycle test. Over 90% of total tailpipe emissions occur during the first minute of the cold-start portion of the FTP75 drivecycle test. As a result, quickly



A chart detailing the catalyst heating spark sweep of the Enerpulse PCI plug

heating up the catalyst to light-off temperature will dramatically effect total emissions. Further testing on a multicylinder thermodynamic engine was recommended to determine whether use of this PCI technology was feasible.

In addition, a test conducted on an advanced multicylinder thermodynamic engine was undertaken and was designed to confirm the findings of the previous experimental engine test. The effect on emissions and exhaust heat flux was studied using ignition timing variation while maintaining a target 15% CoV as the optimization parameter. The tests were conducted on an advanced turbocharged inline-four unit with variable valve timing, gas direct injection and cool exhaust gas recirculation. The test parameter was an ignition timing sweep at 1,150rpm with a 1.8 bar IMEP load.

The spark plug gaps were identical for all plugs tested. In the case of the Enerpulse PCI plugs, the spark gap geometry utilized the Lorentz force effect to project the spark into the combustion chamber by discharging the center electrode to three separate negative electrodes.

Data confirmed that Enerpulse PCI plugs deliver more than double

the exhaust heat flux of the baseline OEM plugs. At a retarded timing 16° after TDC, the baseline spark plug delivers a value of three specific exhaust heat flux at the target of 15% CoV of indicated mean effective pressure. The Enerpulse PCI plug, at the same 15% CoV, delivered more than double (value seven) the specific heat flux at 32° retarded timing.

During the same tests and at the targeted CoV of 15%, the baseline OEM spark plug produced 29g/hr of total hydrocarbon emissions per hour, whereas the Enerpulse PCI plug only produced 15g/hr.

The results gathered by the most recent test conclusively demonstrated the Enerpulse PCI high power plug is able to improve engine stability at highly retarded timing settings. This ability enables faster catalyst light-off, in the process lowering emissions during cold start. The use of Enerpulse PCI high power plugs in engine calibration will reduce total emissions during the critical cold-start phase of the drivecycle certification test. ©

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