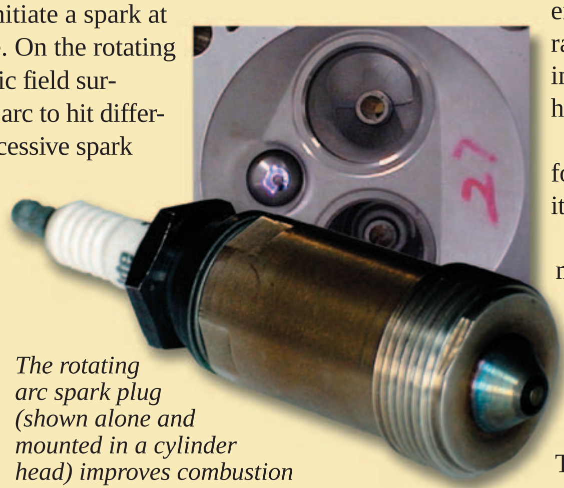
New Spark Plug Ignites Potential of Natural Gas Engines

A new type of spark plug for transportation and stationary power invented at ORNL could help improve fuel economy and reduce emissions in reciprocating engines using natural gas or other hard-to-ignite fuels.

On an ordinary spark plug, an electrical arc crosses an air gap to hit the electrode and initiate a spark at nearly the same point every time. On the rotating arc spark plug (RASP), a magnetic field surrounds the electrode, causing the arc to hit different points on the electrode in successive spark events. Moreover, when the arc contacts the electrode, it travels around the entire surface instead of hitting just a single point. There are several advantages to this approach:



The rotating arc spark plug (shown alone and mounted in a cylinder head) improves combustion under ultra-lean conditions.

- Because the arc contacts more of the fuel volume, the RASP starts combustion more reliably than conventional plugs.
- The RASP produces a much higher plasma temperature, making it easier to initiate an arc.
- The wear on the electrode is reduced by more than one order of magnitude because its surface has more chance to cool between hits, and by another order of magnitude because of the large electrode area.

Because of its higher-power spark, lower erosion rate, and reduced misfiring, the RASP could eliminate the ignition disadvantage for natural gas. In addition, the RASP allows an engine to use a leaner fuel mixture (a higher ratio of air to fuel). A leaner mixture greatly increases fuel economy while reducing exhaust emissions.

Further development of the RASP will focus on improving its reliability and durability over extended periods of use in an engine.

A companion invention, a new erosion measurement technique, allows researchers to analyze the performance of the RASP and of conventional ignition sources. The basis of the technique is a unique, easily identifiable spectral signature of the vaporization produced by every spark event. That signature is used to measure the anode erosion due to the spark discharge and the cathode erosion that occurs in the arc phase.

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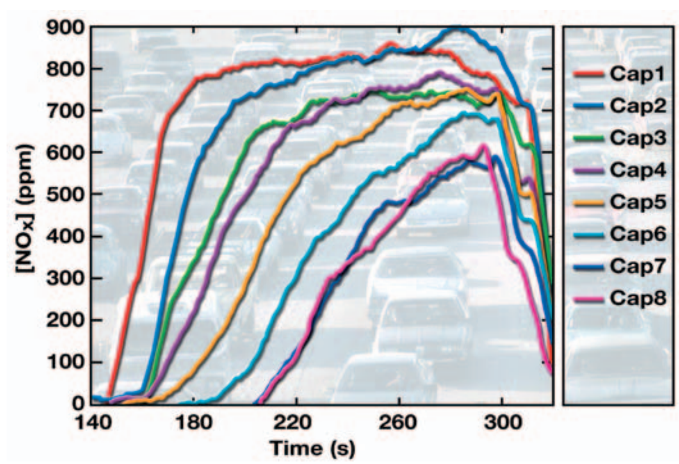
ters with channels that are millimeters wide and several inches long. As exhaust emissions travel along the channels, constant subtle changes occur in their chemistry. Measurement techniques that can resolve these spatial and temporal variations are required to clarify detailed catalyst parameters so catalyst models can be developed. Similarly, efficient EGR requires an EGR/air charge that is well mixed and uniform among cylinders for optimum NO_X control. Methods of evaluating the EGR/air charge must be minimally invasive, so the measurement tool itself does not create additional mixing in the charge.

The ORNL invention, the spatially resolved capillary-inlet mass spectrometer (SpaciMS) has the quick response and minimally invasive nature required for precise, high-speed emissions analysis. Moreover, it can measure a broad range of gases; conventional instruments are typically dedicated to a single species.

The instrument uses tiny (~160-μm outside diameter) glass capillaries inserted into the emissions stream to extract samples (~12 to 60 μL/min) and transport them to the mass spectrometer, which performs at kilohertz rates. The instrument is portable and has been deployed to industrial research labs to evaluate advanced emission-control systems.

In conjunction with industrial partners, ORNL has used the SpaciMS to evaluate advanced exhaust treatment systems for heavy-duty diesel applications.It has been applied by Cummins and EmeraChem to resolve NO_X distributions throughout operating NO_X adsorber catalysts and SO_2 and H_2S distributions in sulfur traps. Cummins has used the SpaciMS to evaluate the performance of EGR system designs for a medium-duty V8 diesel engine Cummins is developing.



Intra-catalyst-channel NO_X distributions charted across space and time at the capillary locations during the adsorption phase.

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