# Champion and ORNL Develop Erosion-Resistant Spark Plugs

## Better Plugs will Improve the Reliability and Performance of Natural Gas Engines

**Background**

ORNL is teaming with spark plug manufacturer Federal Mogul (Champion) to develop new electrode alloys to extend spark plug lifetimes in stationary, natural gas (NG) engines. During FY 2005, Champion manufactured a set of 65 test plugs and sent them to ORNL for engine testing and microstructural analysis. The initial set of plugs included five ORNL developmental alloys and three Champion control alloys. Data gathered in this effort will be used in the continued development of new materials that will extend spark plug electrode life.

Spark plug electrode wear is a major issue in enabling industrial NG reciprocating engines to meet cost, performance, and emission goals. Currently, spark plugs have lifetimes of only about 2–6 months, resulting in poor performance as plugs deteriorate, as well as frequent, costly shutdowns for plug replacement. Ideally, spark plugs for NG engines would have year-long lifetimes, and as NG engine operating conditions move closer to lean-burning combustion to reduce emissions, spark plug reliability and lifetime performance become even more critical.

**Technology**

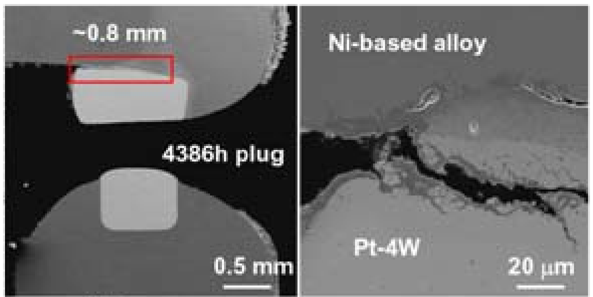
ORNL and Champion are working to identify the key mechanistic contributors to spark plug electrode wear in NG engines and develop improved electrode materials based on this insight. ORNL microstructural and spectroscopic analysis of end-of-life spark plugs from field-operated NG engines identified electrode wear phenomena driven by oxidation and cracking of the electrode materials during engine operation. This finding was unexpected, as wear of spark plug electrodes typically is associated with loss of material due to sputtering, melting, ablation, and particle erosion during sparking.

During FY 2005, a range of field- and engine-tested spark plugs at various stages of wear were systematically studied to determine the relative importance of the oxidation/cracking due to

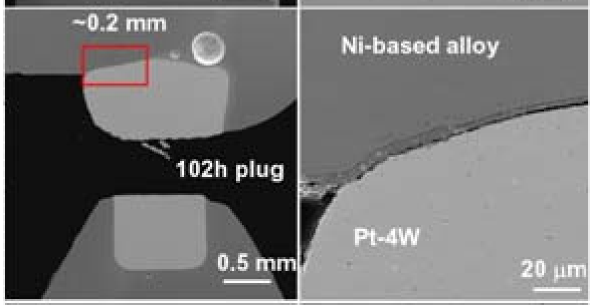

*Experimental NG spark plugs manufactured by Federal Mogul using ORNL advanced alloys*


*CAT G3406 NG engine to be used for spark plug testing* electrode wear. The information from these tests will provide a basis for the development of improved electrode materials to achieve longer spark plug lifetimes.

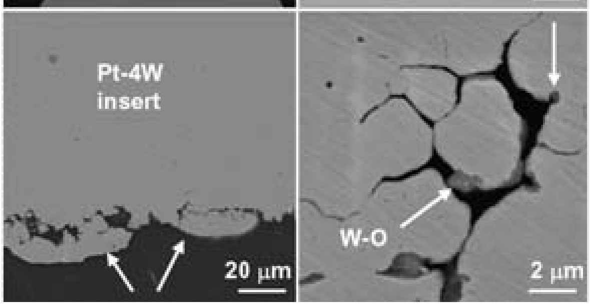
### Key Findings




*Extensive crack growth and oxidation were seen at the platinum-alloy tip insert and nickel-based electrode interface after 6 months of engine testing (left). This phenomenon would significantly degrade the ignitability and performance of spark plugs and is likely a key life-limiting step.*




*Crack initiation and oxidation were observed at the platinum-alloy interface after only a few days of engine operation (left). The observations confirmed the importance of these phenomena to the electrode erosion process and confirmed that they initiate at an early stage of plug life.*




*Substantial intergranular cracks were observed in the platinum-tungsten alloy electrode inserts after only a few days of field service (left). Failed plugs run for up to 6 months were found to have lost up to 40% of their original platinum-alloy electrode material. This cracking was found to result from internal oxidation of tungsten added to the platinum to lower breakdown voltage, followed by volatilization of the tungsten oxide. Coalescence and growth of the cracks associated with this attack would result in flake-off of electrode materials and are likely a major contributor to the loss of platinum electrode material/gap wear.*

### Future Work

The cracking/oxidation wear mechanisms observed at ORNL establish a basis for developing new electrode alloys. ORNL and Champion will continue to work together to manufacture and engine-test conventional J-type spark plugs using new electrode alloys. Several sets of plugs are planned for the initial series of evaluations. They will include electrode alloys selected for improved oxidation resistance and thermophysical compatibility with platinum electrode insert tips.

Several developmental high-melting-point alloys with high corrosion resistance also will be evaluated in place of platinum alloys for the electrode insert tip. These tests will evaluate the potential to prevent the intergranular cracking and associated material loss observed in the platinum alloys tested.

Engine testing and post-test spectroscopic and microstructural characterization of the developmental spark plugs will be pursued in FY 2006.

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