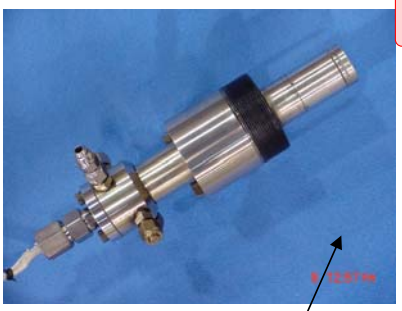
Combustion Control and Diagnostics Sensor (CCADS) for Gas Turbines

U. S. Department of Energy's National Energy Technology Laboratory (NETL)

The combustion control and diagnostics sensor (CCADS) analyzes the electrical properties of the flame to monitor combustion behavior in gas turbine combustors. When important combustion parameters such as air-to-fuel ratio vary, the changes in flame ionization result in a corresponding change of the electrical properties measured using CCADS. The harsh high pressure and temperature environment of gas turbine combustors presents significant challenges for sensor durability. The CCADS is integrated into the combustor fuel nozzle to achieve low cost, ease of installation, and durability.

All combustion processes require a fuel and an oxidizer, usually air. Balance between the fuel and oxidant is critical to ensure that the process is clean and efficient. To maximize efficiency and minimize emissions, many advanced gas turbine systems – the kind that will increasingly be used to generate electricity – employ "lean-premix combustion" techniques. In a lean premixed gas turbine combustor, introducing too little fuel generates excess carbon monoxide, a dangerous pollutant, and too much fuel generates excess nitrogen oxides, which produce smog. Precise metering and mixing of the fuel with the air before combustion minimize production of carbon monoxide and nitrogen oxides. While providing superior pollutant emissions performance, however, lean premixed combustion can suffer from operational problems including pressure oscillations, flashback, and lean blowout. Perturbations from ideal conditions, such as unexpected changes in fuel composition, changes in air pressure and temperature (weather), or engine wear can trigger combustor problems which lead to minor damage and downtime for repair, or even to catastrophic failure that requires replacement of the turbine. As a result, balancing the mixture of air-to-fuel must be performed continually to maintain optimum performance. This continual balancing requires sensors in the combustor to provide key feedback on combustor performance – key feedback which CCADS provides.

Comment [NETL1]: This is not 100% correct, since excess air will lower NOx in most cases. I think we could delete the sentence, but perhaps we need to explain why NOx emissions are bad?



CCADS Prototype

CCADS was developed by researchers in the Office of Science, Technology and Analysis at the Department of Energy's National Energy Technology Laboratory. The research was sponsored by DOE's Advanced Gas Turbine and Advanced Research Programs. NETL researchers have been issued two patents, with other patents pending, on the CCADS technology. A Cooperative Research and Development Agreement was established with Woodward Industrial Controls to design and test a commercial prototype CCADS. The CRADA efforts culminated in 2004 with two successful demonstrations of CCADS in two very different advanced gas turbine designs. Woodward and NETL are working under a second CRADA to address some R&D issues for commercializing CCADS, and Woodward is negotiating with Turbine OEM's for commercial sales. The expectation is that CCADS will provide the key in-situ monitoring for diagnostics and control of modern gas turbines, allowing them to achieve stable ultra-low emissions performance

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