Active Control of a Microturbine Generator (MTG)

OVERVIEW

As installation of Distributed Generation (DG) increases, pollutant emissions of these devices are becoming subject to regulation. Microturbine generators (MTGs) represent a currently marketed DG technology. Looking forward to the eventuality of emissions regulations, we seek technologies to improve emissions, efficiency, and reliability of these MTG systems. Active control provides a method to achieve these goals in both new and retrofit installations by allowing the system to monitor the combustion process and adapt to systematic and environmental changes.

GOALS

- Reduce emissions of a current MTG system from 50 to 100% load to:
  - •10 ppm CO @ 15% O2
  - •3 ppm NOx@ 15% O2
- Investigate sensor technologies to provide feedback
- Determine an authoritative method of control
- Generate correlations to describe the system state based on sensor feedback
- Synthesize components into a robust, cost effective Active Control system.

RESULTS

A Capstone C60 MTG was chosen as the test bed for this project. Due to the staged firing method used in the C60 it was determined that a control system capable of modulating air flow to each injector was required. This allows the Active Control system to maintain appropriate local equivalence ratios at each injector. Local equivalence ratio information is supplied by an optical fiber inserted into the injector and looking into the combustor. High speed chemiluminescence data is collected by a photo multiplier tube. The data is then analyzed by a novel method involving the power spectral density to determine the CO and NOx emissions levels. Once emissions levels are determined, the system adjusts the variable geometry injector based on an emissions costing function.

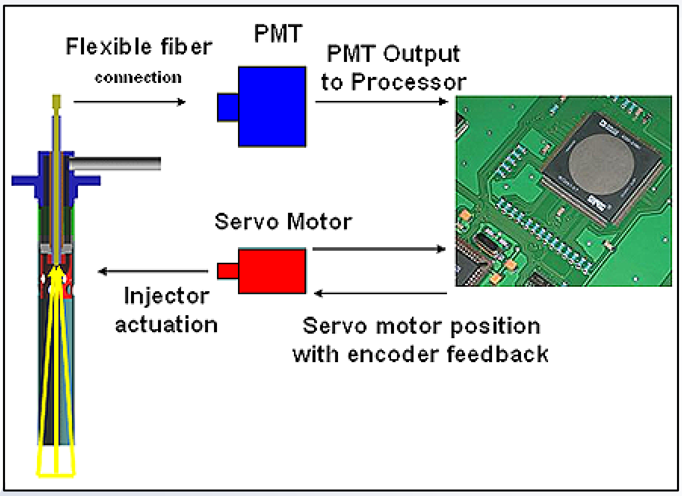

Figure 1. Synthesis of an active control system

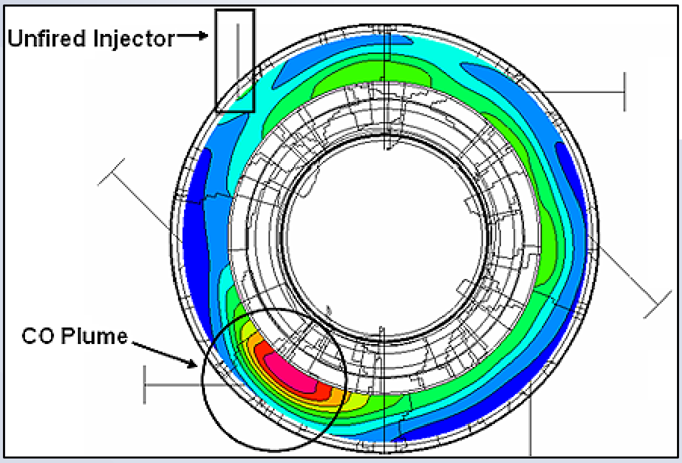

Figure 2. Capstone C60 Combustor Exit Plane CO Concentration (CFD Simulation)

Reduction of CO by more than 80% has been observed by the use of simple variable geometry injectors. Corresponding increases in NOx emissions were not observed indicating that the high CO levels are due to downstream mixing. By removing the sequential firing method and firing all injectors continuously, the dependence of CO on downstream mixing is greatly reduced. NOx and CO emissions are then more directly dependent on local equivalence ratios at the injector tips. This allows the optical fibers to capture the main characteristics of the combustion process by looking only at the local equivalence ratio of each injector.

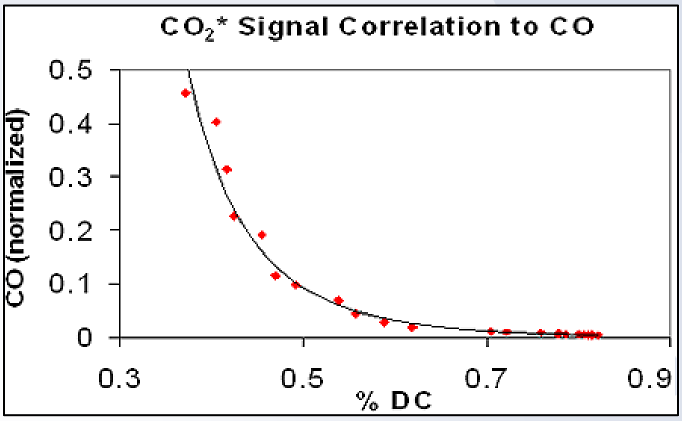

Figure 3. Emissions correlations to the chemiluminescence signal allow adaptive operation

PERSONNEL

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