Hydrogen in Gas Turbine Engine

OVERVIEW

Distributed generation (DG) sources are tasked with producing high quality, localized, cost effective and reliable power. Historically this has been accomplished with technologies such as diesel fueled internal combustion generators. Though this type of technology worked well for shot periods of time the air pollution impacts created are unacceptable for long term operation. The requirements placed on DG can be realized in an environmentally sensitive way through the use of microturbine generators (MTG). Currently MTGs are fueled primarily by natural gas and liquid fuels. Hydrogen has become the subject of great interest as a possible replacement for hydrocarbon fuels for economic and environmental reasons. This research project couples the interest in both DG and hydrogen to determine the feasibility and challenges hydrogen fueled MTGs.

GOALS

- Fundamental study of hydrogen and possible challenges with its use in MTGs.
- Redesign of current C60 natural gas injectors to be fueled with hydrogen based upon fundamentals study.
- Test redesigned system for emissions.

RESULTS

An initial study of hydrogen's fundamental properties highlighted the vast difference between this new fuel stock and the current natural gas. Important factors include: heating value, species size, flame speed, ignition delay and flame temperature. Hydrogen contains a heaving value approximately three times less than that of natural gas. Because of this to maintain the 60kW desired output a larger volumetric flow rate will be required to supply the engine. This could pose a problem due to the limited area available for fuel distribution and injection. This problem is alleviated due to the fact that hydrogen is approximately three times smaller than that of natural gas. Turbulent hydrogen reaction travel at a rate of approximately 139 ft/sec, 5.7 times greater than that of natural gas. The C60 injector expels gas at a velocity of 145 ft/sec leaving the potential for a stable reaction in the injector possible. The time required for a hydrogen/air mixture to spontaneously combust is very similar to that of a natural gas/air mixture. This similarity reduces the concern of possible auto ignition. Hydrogen combustion produces gas temperatures around 125K greater than natural gas combustion for a given equivalence ratio. To ensure the combustion chamber is not compromised the primary zone equivalence ratio needs to be keep at a point so the reaction temperature is similar or lower than that of the natural gas reaction. This limits the hydrogen equivalence ratio to a maximum of 0.35. A design integrating these fundamental properties has been developed. Atmospheric testing has been performed to quantify velocity and mixing parameters. Emissions testing will be done with the C60 and correlated to the benchmark testing.

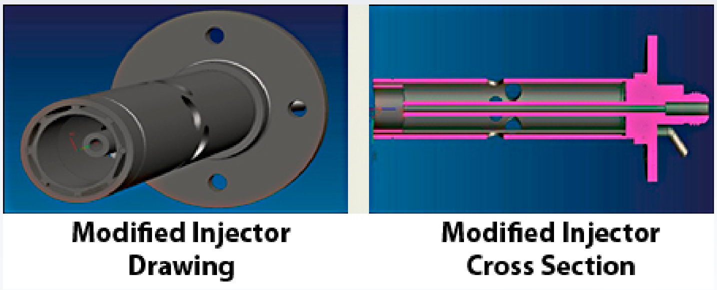

Figure 1. Modified Injector

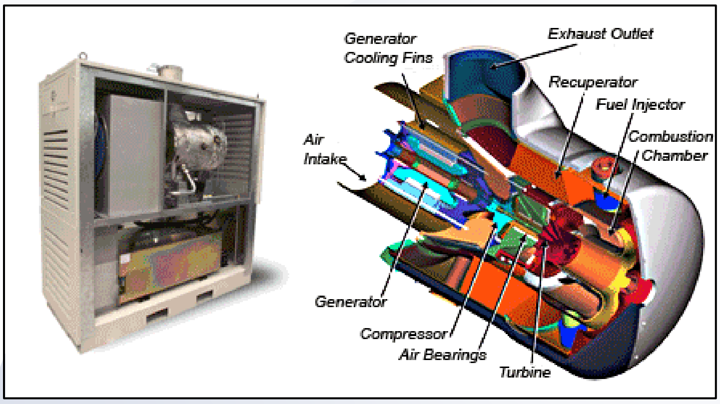

Figure 2. Capstone C60 and Engine Detail

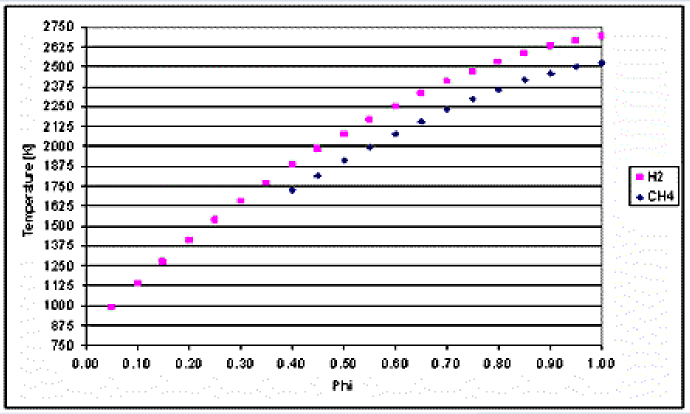

Figure 3. Adiabatic Flame Temperatures for Methane and Hydrogen

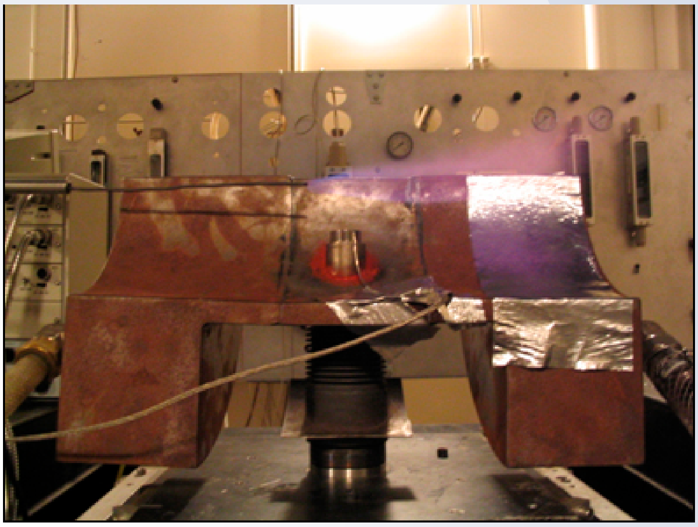
Figure 4. Atmospheric Flash Back Testing

PERSONNEL

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PROJECT PARTNER

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