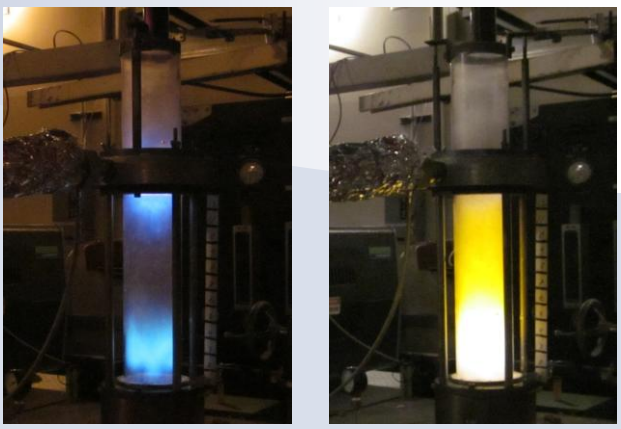
Exhaust Enthalpy Control Unit

OVERVIEW

Increased interest in distributed power generation has lead to increased interest in combined heating cooling and power (CCHP). One significant issue in implementing a CCHP is that electrical loads and heating or cooling loads are rarely synchronized. Duct burners are frequently used to provide additional heat when the waste heat available from the prime mover does not meet the needs of the heat recovery device. Duct burners are required to operate on vitiated oxidizer streams which can result in poor stability, poor emissions, or both. With increasingly stringent emissions regulations, the contribution of emissions from the duct burner can be a significant limiting factor. Rich-burn, quick-mix, lean-burn (RQL) style combustors have been shown to provide low emission and high stability in lean gas turbine applications. This work was performed to assess the merits of using a RQL style combustor in a supplemental firing application.



RQL Combustor in Operation
Left: 21% O2 inlet, Mass ratio of 2.0, 15° swirl
Right: 17% O2 inlet, Mass ratio of 1.5, 15° Swirl

GOALS

The objective of the present work is to evaluate the potential for an RQL based low emissions, modular, natural gas fired burner which can operate effectively in vitiated oxidizer streams like those found the exhaust stack of a gas turbine. This result will be achieved by accomplishing three goals:

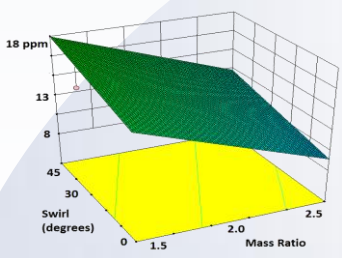
•Characterize the effects of oxidizer vitiation on an RQL combustor

•Optimization of an RQL combustor for use in vitiated conditions through manipulation of rich zone swirl level, mixing air-to main mass ratio, and number of mixing jets.

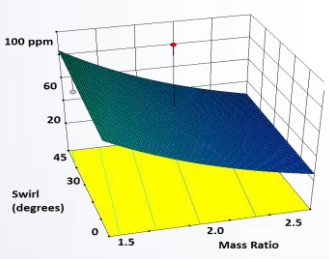
•Construction and testing of full scale combustor for use with a microturbine generator.

RESULTS

Based on the current data it was determined that an RQL type supplemental burner can be used to reduce the NOx present in the exhaust gas of a gas turbine engine. A mixing air-to-main air mass flow ratio of 2.5, the highest tested, produces the lowest emissions of NOx and CO at a fixed equivalence ratio, but that higher mass ratios produce narrow limits of operability. An important observation was that at high mass ratio, the sensitivity of emissions to oxidizer vitiation is greatly reduced. It was determined that a decrease in the level of rich zone swirl was beneficial in the reduction of NOx emissions, with the lowest NOx emissions being found with only 5° of swirl. However, this reduction in swirl also tends to destabilize the rich zone.



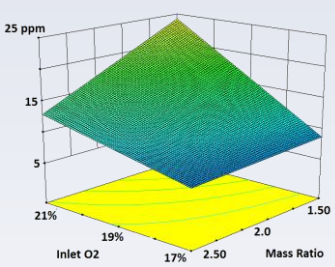
NOx Emissions vs. Swirl and Mass Ratio



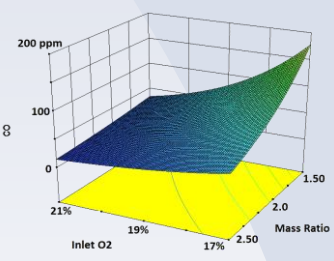
CO Emissions vs. Swirl and Mass Ratio

RESULTS (continued)

It was observed that at mass ratios above 2.0, a mixing section with 5, the fewest tested, orifices produced the lowest NOx and CO levels. CO emissions tend to be higher at the same conditions where NOx is reduced the most, typical of many combustion systems. Because the effect of oxidizer vitiation, which cannot be held constant in practical systems, has a much more significant effect on the emission of CO than any change in mass ratio, a practical design practice would be to choose a combustor geometry that best controls NOx and use other means to mitigate the CO emissions.



NOx Emissions vs. Inlet Oxygen Concentration and Mass Ratio



CO Emissions vs. Inlet Oxygen Concentration and Mass Ratio

RECENT PUBLICATIONS/PAPERS

E. Sullivan-Lewis, V.G. McDonell, R.L. Hack, (2011). *Evaluation of a Rich Burn, Quick Mix, Lean Burn Combustion System Operated in a Vitiated Air Stream*. Proceedings the Fall Technical Meeting of the Western States Section of the Combustion Institute

E. Sullivan-Lewis, V.G. McDonell, R.L. Hack, (2011). *Development of a Modular Supplemental Burner for Optimization of Distributed Generation/Combined Heat and Power System Efficiency*. Proceedings of the 2011AFRC Meeting

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