Fuel Flexible Microturbine and Gasifier System for Combined Heat and Power

OVERVIEW

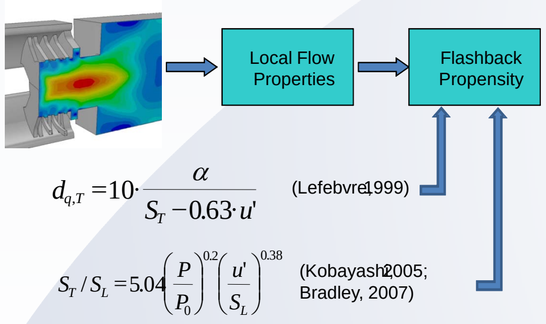
Microturbine (MT) combined heat and power (CHP) systems combine a small gas turbine, an electric generator, and a heat exchanger to efficiently produce electricity and heating. Unstable natural gas prices, actions toward carbon emissions regulation, and excess risk from reliance on a single fuel source, have made the utilization of alternative fuel sources attractive from both environmental and economic standpoints. A renewable fuel source such as biomass could reduce these risks, and integration of the MT and a biomass gasifier could provide a self-contained solution. The gasifier to be used in this effort is one developed by Packer Engineering. The synthesis gas it produces has a high hydrogen content posing problems with regard to operability of the combustor in particular that of flashback. Other significant technological barriers are stable synthesis gas composition given variation in feedstock and the system integration itself. The UC Irvine Combustion Laboratory will be supporting Capstone Turbine Corporation in the modification of the combustor and injectors such that stable operation on the high hydrogen content synthesis gas is achieved. UCI has several test stands specific to Capstone hardware that will be utilized in this project.

GOALS

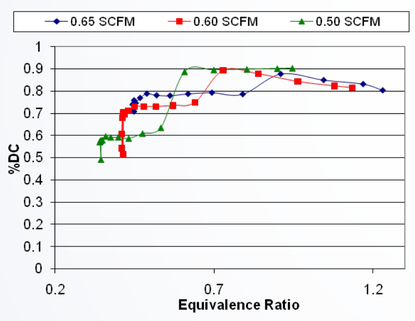
- Modify current injector and combustor designs for operation on high hydrogen content fuels while maintaining low emissions..
- Build and demonstrate a prototype turbine-generator system and integrate with it with a gasifier,
- Evaluate system to verify performance and emissions.

RESULTS

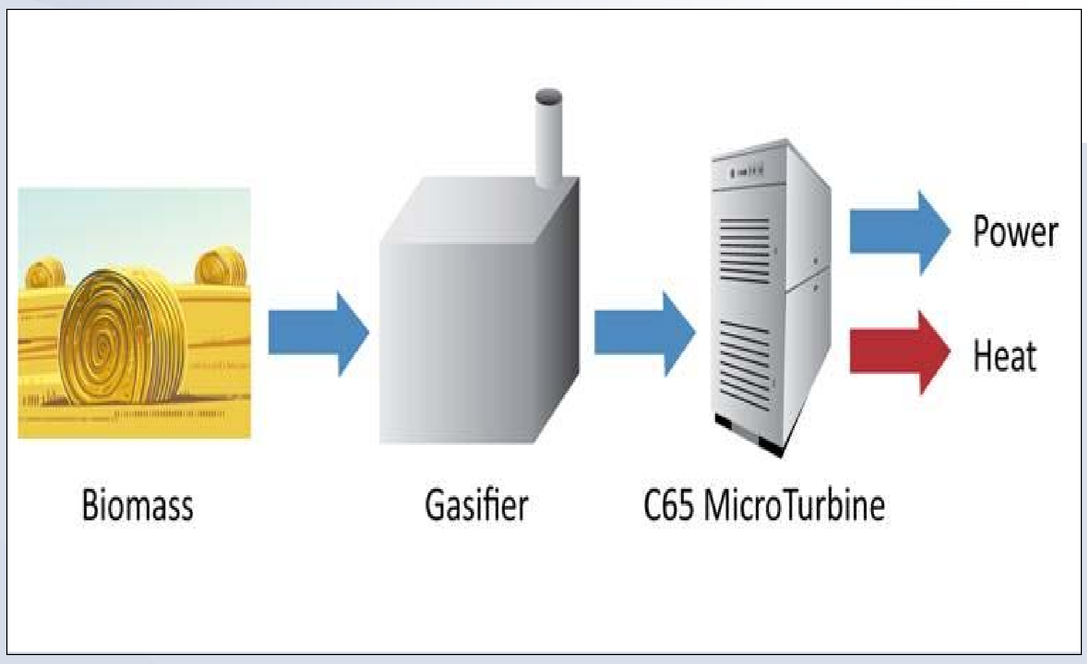
Flashback is the main challenge associated with operating the microturbine on a high hydrogen content fuel. Boundary layer and core flow propagation are the two propagation mechanisms relevant to this project. Using conservative estimates of turbulent flame speeds, boundary layer propagation is more likely than core flow propagation.



Flashback propensity analysis method



Previous UCICL use of photomultiplier tube for flashback detection

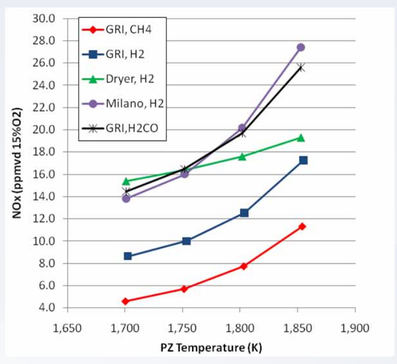


Integrated Microturbine Gasifier Concept

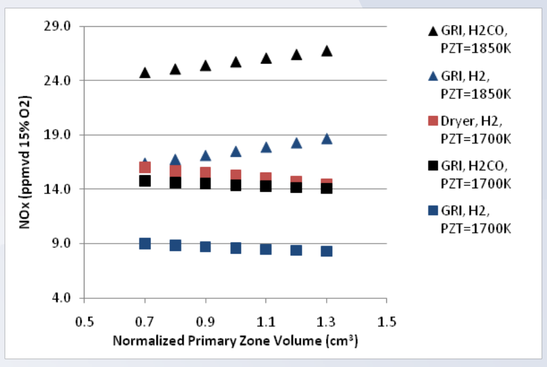
RESULTS (continued)

A Flashback propensity analysis method developed here at the UCICL involves the use of CFD combined with experiments to allow for effective screening of and analysis of different injector designs (Wang, 2008). With the Capstone specific test stands already utilized here at the UCICL , experiments can be performed along with CFD simulations to determine the flashback propensity of different injector designs. Flashback detectors will also be evaluated.

Another technical barrier that UCI is supporting Capstone in is maintaining low emissions despite operation on a high hydrogen content fuel. Previous operation of a microturbine on pure hydrogen here at the UCICL resulted in much higher NOx emissions.



Chemkin well stirred reactor analyses



Chemkin well stirred reactor analyses

RECENT PUBLICATIONS/PAPERS

Wang, Q., McDonell, V.G., and Samuelsen, G.S. (2009). Correlating flashback tendencies for premixed injection of hydrogen and methane mixtures at elevated temperature and pressure. Paper GT-59500, ASME Turbo Expo 2009, Orlando, FL.

PERSONNEL

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