Project #30
NJFCP Area #6: Referee Swirl-Stabilized Combustor Evaluation / Support

Motivation and Objectives

Motivation:

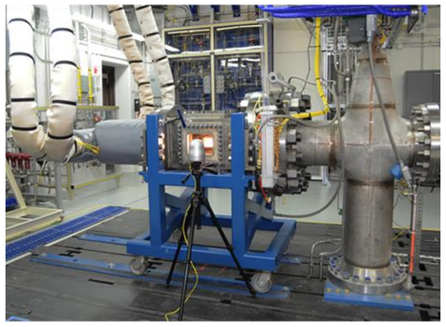
Requirement for a realistic combustor to be used as a referee for the effect of alternative fuels on combustion characteristics

Objectives:

To develop conduct, and analyze combustion experiments with emphasis on ignition and lean blowout for conventional and alternative fuels in the NJFCP program referee combustor

To provide high fidelity experimental initial condition and validation data for computational modeling teams

Methods and Materials



Referee Combustor Rig at AFRL

Experiments are performed in cooperation with Air Force Research Laboratory at Wright-Patterson Air Force Base

Single Cup Combustor Incorporates:

-Hybrid two-stage nozzle and swirler
-Two stages of dilution
-Advanced effusion cooling
-Provision for instrumentation and optical access

Rig enhanced with :

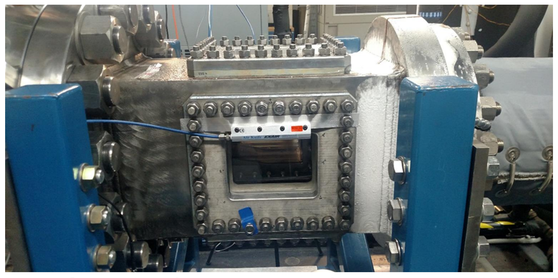
-Optical accessibility for diagnostics
-Development of low temperature fuel and air systems
-Fine control of air & fuel temperatures, pressures, and flowrates

Summary

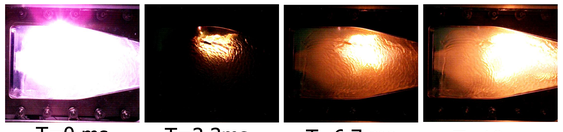
Experimental comparison of combustion characteristics for alternate and conventional jet fuels in swirl-stabilized single-cup (referee) combustor

Significant differences measured between conventional fuel (A-2) and the alternative fuels for lean blowout (LBO), and ignition characteristics

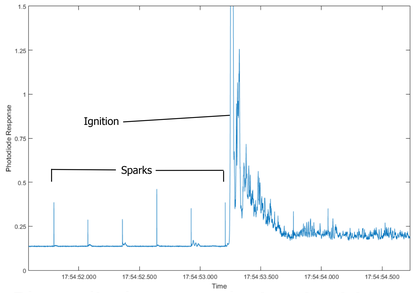
Cold fuel and cold air capability recently installed. Initial studies show that the cold fuel and air temperatures affect the ignition characteristics



Referee Combustor Test with $T_{fuel} = T_{air}$ =-30°F



Video sequence of spark ignition



Photodiode trace during ignition test

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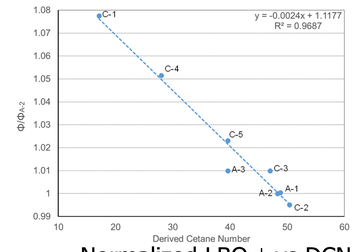
Results and Discussion

Lean blowout data shows significant differences between alternative and conventional fuels

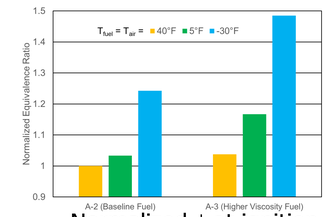
A strong correlation found between LBO equivalence ratio and Derived Cetane Number (DCN)

Further cross experimental analysis underway for LBO data for other experiments

Initial results for cold fuel/air ignition study show that the combustor is more difficult to ignite at low fuel/air temperatures and highlights the detrimental effect of higher viscosity fuels on ignition



Normalized LBO ϕ vs DCN



Normalized ϕ at ignition

Conclusions and Next Steps

Conclusions :

Ignition and LBO sensitivity to fuel type has been demonstrated

Strong correlation of LBO equivalence ratio (ϕ) shown for NJFCP fuels with Derived Cetane Number (DCN)

Cold fuel and air systems functional and cold start experiments currently underway

Next Steps:

Further ignition experiments at fuel/air temperatures down to -30°F with more fuels

Extension of facility capabilities to conduct altitude relight studies at conditions comparable to ~30,000 ft

Implementation of advanced optical diagnostics

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