

Operability of an Annular Combustor with High Hydrogen Content Fuels

OVERVIEW

Operability issues such as flashback and lean blow out are phenomena that must be addressed for successful commercial operation of stationary gas turbines. The present work focuses on flashback and lean blow out of premixed jet flames in a combustor from a commercially available gas turbine operating on synthesis gas compositions. The issue of flashback is exacerbated when operating on fuels with high hydrogen content due to the increased reactivity of hydrogen, thus increasing the propensity for flashback.

OBJECTIVES

- Compare operating limits for mixtures of H₂/CO and H₂/NG
- Investigate how preheat influences flashback and blowout
- Correlate flashback and blowout results
- Compare data to previous work in literature

RESULTS

Testing done in the annular combustor has identified different flashback characteristics between H₂/CO and H₂/NG. While operating on H₂/NG there is a lack of operability region as the concentration of H₂ increases in the fuel. The effect of H₂ addition is shown in Figure 2 indicating that H₂/CO maintains operability to 100% H₂.

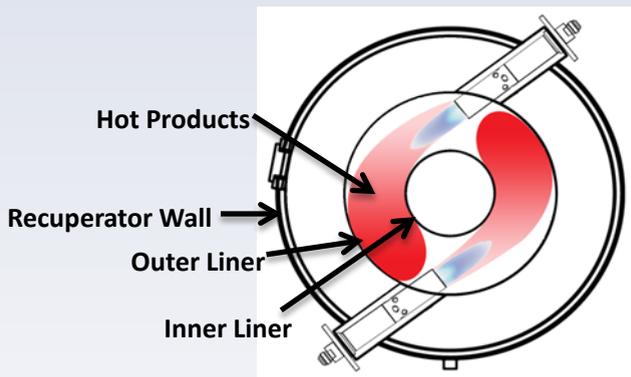


Figure 1: Lower injector plane of combustor

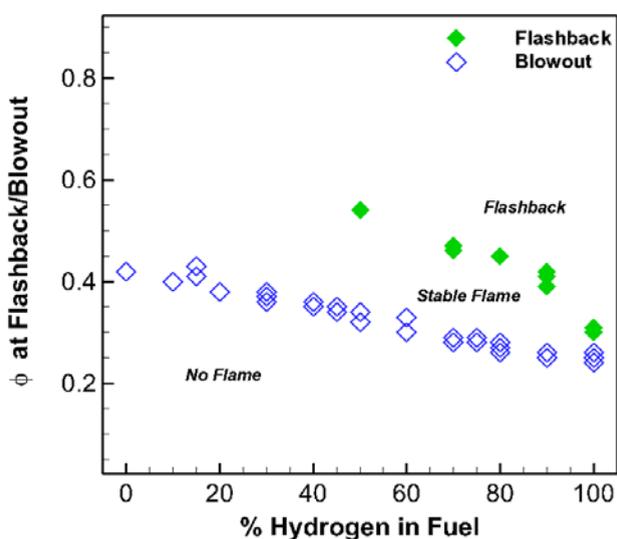


Figure 2: H₂/CO margins between flashback and blowout

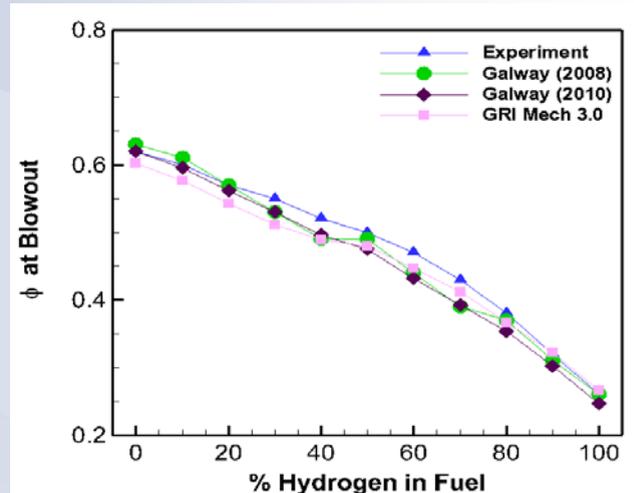
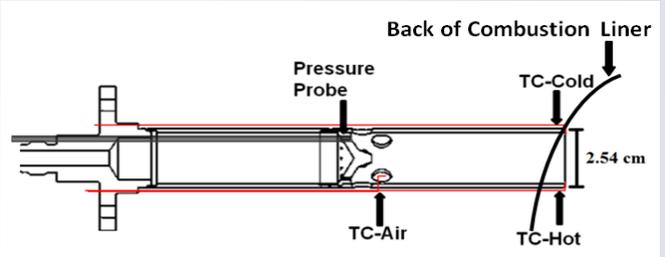


Figure 3: Prediction of lean blowout using a perfectly stirred reactor

Figure 3 shows the predicted extinction limits of the PSR analysis for H₂/NG fuel mixtures. Results agree relatively well for all mechanisms, especially at the lower and upper limits. At the start of the tests the EQ is set very close to the LBO because this is the only point where a semi-stable flame is possible for an extended period of time. These compositions blow out right as the EQ decreases. In the latter points that agree the EQ are set farther above the LBO limit and allowed to gradually approach the limit which might account for the better agreement in the model.

Other factors influencing flashback, such as preheat temperature, adiabatic flame temperature, and laminar flame speed are investigated. Results indicate that for a given concentration of H₂ in the fuel flashback occurs at the same adiabatic flame temperature regardless of preheat. The calculation of AFT for the H₂/CO mixtures revealed that AFT at flashback and lean blowout does not vary as inlet air preheat is changed from 300 K to 672 K. However, for the H₂/NG mixtures, the AFT at flashback and lean blowout did still depend on the preheat temperatures although to a lesser extent. This further illustrates the differences between the two sets of mixtures.



RECENT PUBLICATIONS/PAPERS

Establishing Operating Limits in a Commercial Lean premixed combustor operating on synthesis gas pertaining to flashback and blowout

Proceedings, ASME Turbo Expo 2012, Copenhagen, Denmark (D. Page, B. Shaffer, and V.G. McDonell).

PERSONNEL

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