Abstract for an Invited Paper
for the GEC08 Meeting of
The American Physical Society

Jet Diffusion Flame Stabilization via Pulsed Plasma Forcing[1]

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In this work we investigate the use of high repetition rate pulsed plasma sources as a means to enhance the stability of jet diffusion flames for application to practical combustion devices. Such plasma sources have recently become popular owing to their low power requirements and their proven abilities to ignite leaner mixtures and hold stable flames. They are known to create a radical pool which can enhance combustion chemistry and thus provide increased flame stability. By first investigating a fully premixed methane/air environment we show that the resulting radical species quickly decay but leave behind a set of stable chemical species. Thus, the plasma source appears to act as a fuel reformer leading to the formation of a "cool flame" – a trailing zone of weak oxidation consisting of a slightly elevated temperature stream of products containing small amounts of hydrogen and carbon monoxide. These two key species are then directly responsible for the enhanced flame behaviors. Flame stability enhancements are shown for methane jets in co-flow and cross-flow in room temperature air, and in elevated temperature vitiated air environments. Elevated ambient temperatures deplete the hydrogen and carbon monoxide due to enhanced oxidation, so while there is an enhancement to flame stability, the beneficial effects diminish with increasing temperatures in a non-linear fashion, and ultimately, provide very limited benefits at ∼1000K ambient temperature for the present studies. The conclusions here are supported by simple plasma and chemical kinetic modeling and spectroscopic and chemiluminescence measurements.

[1]Supported by AFOSR MURI and STTR programs with Julian Tishkoff as Contract Monitor.