Graduate Colloquium, Aerospace Engineering

WPI

Selected Cool Flame Phenomena

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Significant research associated with cool flames and transitions to hotter flames for large molecular weight alkane fuels has been performed. Much of this prior work reports ignition delay times for cool flames and then for transition to hot flames as a function of various parameters and describes development of detailed reaction mechanisms that simulate such phenomena. This paper addresses two aspects of cool flames that have received less focus: **(Q1) why does a cool flame stop burning, even though sufficient reactants remain unburned, and (Q2) can an equivalence ratio of a cool flame be defined, given that the ratio of the oxidizer to original fuel consumed in the cool flame varies significantly from the starting ratios of their concentrations**? To examine these questions, we use simulation results from a detailed chemical kinetic model for combustion of n-dodecane over a range of conditions. Where possible, we also examine recent experimental data sets for comparisons to our conclusions.

In the case of **Q1, we consider three possibilities: A. Chemical heat release pushing reactions into the slower NTC region (traditional explanation for termination of cool flames), B. Depletion of the parent fuel leading to slower overall reaction rates. And C. Supply of hydro-peroxide and other high MW product species produced during induction and/or in the flame becomes exhausted, shutting down the chain branching processes.** Each phenomenon is considered and assessed for their role in the termination of the cool flame reactivity. In addition, the relative consumption of O2 vs. n-dodecane is tracked and compared over a variety of conditions, as well as typical product distributions resulting from the cool flame reactions. Comparisons to high temperature ignition phenomena for (high MW) hydrocarbon fuels in which the parent fuel pyrolyzes to a set of product species that govern subsequent ignition times are considered.

Med Colket received M.A. and Ph.D. degrees in Aerospace in Mechanical Sciences from Princeton University under Professor Irvin Glassman and a B.S from Cornell University. He joined United (now Raytheon) Technologies Research Center in Connecticut, retiring in 2014 as a Senior Fellow after 37 years. He has since remained active in the technical community, and recently was a technical coordinator for the National Jet Fuels Combustion Program, and was an associate editor of Combustion Science and Technology. He is co-editor of Fuel Effects on Operability of Gas Turbine Combustors, a recent publication in AIAA's Progress Series. He is an internationally recognized expert in the field of chemical kinetics and combustion of hydrocarbon-based fuels, with specialties in pollutant formation, jet fuels (including sustainable aircraft fuels), flame stability and fire suppression. He has authored over 50 peer-reviewed publications and holds fifteen patents primarily for innovative ideas in endothermic fuels for high-speed flight, low NOx combustion concepts, and combustion control techniques.