Boulder Fluid and Thermal Sciences Seminar Series

Tuesday, November 14, 2017
3:30pm-4:30pm (refreshments at 3:15pm)
Bechtel Collaboratory in the Discovery Learning Center
University of Colorado, Boulder

Gasoline Droplet Evaporation and the Role of Oxygenates on In-Cylinder Particulate Matter Formation

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In previous studies, a relationship has been observed between increasing ethanol content in gasoline and increased particulate matter (PM) emissions from direct injection spark ignition engines. The fundamental cause of the PM increase seen for moderate ethanol concentrations (15-50 vol%) is not well understood. As a result, existing PM indices such as PMI may not be indicative of measured PM emissions for oxygenated biofuel blends. Ethanol features a higher heat of vaporization (HOV) than gasoline and also influences vaporization by altering the liquid and vapor composition throughout the vaporization process. A droplet vaporization model was developed to explore ethanol's effect on the evaporation of aromatic compounds known to be PM precursors. The evolving droplet composition is modeled as a distillation process, with non-ideal interactions between oxygenates and hydrocarbons accounted for using UNIFAC group contribution theory. Detailed hydrocarbon analysis was applied to fuel samples, and used as input for the initial droplet composition. The droplet can be modeled in terms of energy transfer, which in turn provides the transient mass transfer, droplet temperature, and droplet diameter. Model predictions suggest that non-ideal vapor-liquid equilibrium along with an increase in HOV can alter the droplet composition evolution. Results predict that the presence of ethanol causes enrichment of the higher boiling fractions (T90+) in the aromatic components as well as lengthens the droplet lifetime. A simulation of the evaporation process in a transient engine cylinder environment predicts a decrease in mixing time of the heaviest fractions of the fuel prior to spark initiation, possibly explaining observations linking ethanol to PM. Preliminary data exploring the role of vaporization on soot formation in flames is also presented.

Biography: Dr. Bret Windom graduated with his PhD in Mechanical and Aerospace Engineering from the University of Florida in 2009. Following graduation, Dr. Windom was awarded an NRC postdoc to work in the Thermophysical Properties Division at the National Institute of Standards Technology (NIST) in Boulder, CO. After NIST, Dr. Windom carried out a roving postdoctoral fellowship in the Combustion Energy Frontier Research Center (CEFRC) at the University of Southern California and Princeton University. Dr. Windom held a faculty position at the University of Colorado Colorado Springs (UCCS) in the Mechanical and Aerospace Engineering Department from 2013 – 2016. Beginning in the fall of 2016, he joined the Mechanical Engineering Department at Colorado State University as an assistant professor. Dr. Windom is the supervisor of the Chemical Energy Conversion Laboratory where he oversees research projects ranging from the characterization of key physical and chemical properties of fuels and their impact on turbulent and laminar flame stability/dynamics, and emissions.