The combustion dynamics and stability are dependent on the quality of mixing and vaporization of the liquid fuel in the pre-mixer. The vaporization characteristics of different blends of biofuel droplets injected into the air stream in the pre-mixer are modeled in this current study. The focus of this work is on the blended alternate fuels which are lately being considered for commercial use. Two major alternate fuels analyzed are ethanol and Rapeseed Methyl Esters (RME). Ethanol is being used as a substitute for gasoline, while RME is an alternative for diesel. In the current work, the vaporization characteristics of a single droplet in a simple pre-mixer has been studied for pure ethanol and RME in a hot air jet at a temperature of 800 K. In addition, the behavior of the fuels when they are mixed with conventional fuels like gasoline and diesel is also studied. Temperature gradients and vaporization efficiency for different blends of bio-conventional fuel mixture are compared with one another. The model was validated using an experiment involving convection heating of acoustically levitated fuel droplets and IR-thermography to visualize and quantify the vaporization characteristics of different biofuel blends downstream of the pre-mixer. Results show that the 20 μm droplets of ethanol-gasoline 50-50 blend is completely evaporated in 1.1 msec, while 400 μm droplets vaporized only 65% in 80 msec. In gasoline-ethanol blends, pure gasoline is more volatile than pure ethanol. In spite of having higher vapor pressure, ethanol vaporizes slowly compared to gasoline, due to the fact that latent heat of vaporization is higher for ethanol. For gasoline-ethanol blended fuels, ethanol component vaporizes faster. This is because in blended fuels gasoline and ethanol attain the same temperature and ethanol vapor pressure is higher than that for gasoline. In the case of RME-diesel blends, initially diesel vaporizes faster up to 550K, and above this temperature, vapor pressure of RME becomes dominant resulting in faster vaporization of RME.

Current work also looks into the effect of non-volatile impurities present in biofuels. Depending on source and extraction process, fuels carry impurities which impact vaporization process. In this work these effects on ethanol blended fuel have been studied for different concentration of impurities. The presence of non-volatile impurities reduces the vaporization rate by reducing the mass fraction of the volatile component at the surface. However, impurities also increase the surface temperature of the droplet.

Finally, the effects of hot and cold spots in the prevaporizer have been investigated. Due to inefficient design, prevaporizer may have local zones where the temperature of air increases or decreases very sharply. Droplets going through these abnormal temperature zones would vaporize at a different rate than others. Current study looks into these droplets to understand the vaporization pattern.

Educational Career:
Bachelor's of Mechanical Engineering, BS, 2006, Jadavpur University, India

Approved for distribution by Ranganathan Kumar, Committee Chair, on May 24, 2010.

The public is welcome to attend.