Turbulent Combustion Analysis of Large Hydrocarbon Fuels in a Reduced Pressure Environment

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Abstract

The aviation industry is pushing for better fuels and gas turbine engines for several reasons: cost, emissions, and to a lesser extent high-altitude relights. One aspect that research has been focused on to help reduce costs, emissions and better understand high-altitude relights is studying the combustion behavior of the fuel being supplied (e.g., large hydrocarbon fuel). Understanding the combustion behavior of these fuels can bring new possibilities for incorporating alternative fuels and developing new combustor designs. A parameter that is commonly used to help measure and analyze the combustion behavior is the turbulent consumption speed and the mass burning flux. The objective of this work is to understand the effects of different flow conditions (e.g., varying Reynolds number and turbulence intensities), chemical sensitives (e.g., burning of different fuels at different equivalence ratios), and reduced pressure effects on the turbulent consumption speed and the mass burning flux.

The turbulent consumption speeds in this work ranged from 1 to 3 m/s for four different fuels: jet-A, ATJ Gevo, C10/TMB, and a surrogate fuel. The turbulent consumption speeds on average increased about 10\% with a 30\% decrease in pressure. ATJ Gevo was found to be the most sensitive to pressure effects out of the four fuels tested with increases of about 15 to 20\% in turbulent consumption speed. The turbulent burning flux values ranged from 0.5 to 2 kg/s-m^2. The burning flux on average decreased about 30\% with a decrease in pressure. The turbulent consumption speeds where scaled by the zero-stretch laminar flame speed and the values range from 2 to 4. The sensitivity of the normalized turbulent consumption speed to pressure was attributed to the changes in the density of the unburned mixture. At fuel-lean conditions, breaks in the flame tip were observed. A method was created to quantify when the flame became unstable. It was found that ATJ Gevo was the most sensitive to fuel-lean conditions, having the smallest stability range of the four fuels.

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