Spray and Combustion Characteristics of Potential Alternative Aviation Fuels and Jet A-1 in a Swirl-Stabilized Combustor

Abstract

Significant growth in the aviation industry has also raised concern about the impact of this sector in terms of environmental pollution. Bio-derived fuels are going to play an important role as potential alternative aviation fuels in the near future to mitigate the carbon footprint. In the first part of the thesis, spray characteristics of kerosene-based fuel (Jet A-1) and alternative aviation fuels such as butyl butyrate, butanol, limonene and their blends with Jet A-1 are investigated using an air-blast atomizer under different atomizing air-to-fuel ratios. The higher viscosity of butanol causes higher SMD, and the droplet formation seems to be delayed compared to Jet A-1. In contrast, the lower viscosity of butyl butyrate promotes faster droplet formation. In the second part, the combustion characteristics of listed fuels are investigated in a swirl-stabilized gas turbine-type combustor. For a comparative assessment, the theoretical power output is kept constant for all the fuel cases by suitably adjusting the fuel flow rates based on the lower heating value of the fuels. Visualization of flame, measurement of temperature inside the flame, and exhaust emissions at the combustor exit are carried out to compare the performance of various fuels relative to Jet A-1. 50% butanol-loaded blends show a reduction of 29 % CO and 24 % NOx compared to neat Jet A-1 whereas 30% loading follows a similar trend, and the pollutant emission is slightly higher than the 50% blend case. Additionally, both 30% and 50% butanol blends show a comparable flame temperature distribution, which is higher than neat Jet A-1. Irrespective of preheating, pure butyl butyrate and blends exhibit significantly lower CO emissions compared to Jet A-1. Compared to pure Jet A-1, the flames of limonene and limonene/Jet A-1 blends have given good results in terms of pollutant emissions and temperature profiles when limonene is added to Jet A-1. 50% limonene-loaded blends show a drop of 15% CO and neat limonene show a 35 % CO reduction. Additionally, 10%, 30%, and 50% limonene blends have shown better combustion characteristics compared to neat Jet A-1.