

REGULAR PAPER

Spray behaviour of hydro-treated ester fatty acids fuel made from used cooking oil at low injection pressures

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Abstract

The spray characteristics significantly affected the combustion performance. The injection pressure and fuel properties are factors that affect the spray cone angle, penetration, and droplet distribution. Although substantial research has been conducted on spray attributes, understanding the complex biofuel spray dynamics in real nozzles and injectors is crucial. This study examines hydro-processed esters and fatty acid (HEFA) spray characteristics of used cooking oil and palm oil biodiesel in a constant-volume chamber. The study was performed by varying the injection pressures ranging from 30 to 120psi for pure fuels and Jet A-1 blends. Experiments were conducted at standard sea-level atmospheric pressure and an ambient temperature of $\pm 297\text{K}$ using an airblast fuel injector. The initial fuel temperature was set at $\pm 302\text{K}$. Jet A-1 was used as the baseline fuel for the comparative analysis. Particle image velocimetry (PIV) was employed to visualise the microscopic and macroscopic characteristics of the fuel spray. The results revealed a progressive increase in the penetration length corresponding to an increase in the injection pressure. Lower pressures yielded non-uniform particle distributions across the spray area, whereas cone angle augmentation stabilised at elevated pressures. A blend of 60% Jet A-1 and 40% HEFA closely matched Jet A-1 characteristics, indicating alternative aviation fuel potential. These real-time insights into spray behaviour are critical for enhancing the fuel efficiency and mitigating the generation of particulate emissions resulting from spray combustion.

Nomenclature

ASI	start of injection
BD100	100% (pure) biodiesel
FAME	fatty acid methyl ester
H100	100% (pure) HEFA
HEFA	hydro-processed esters and fatty acids
J40H60	blend of 40% Jet A-1 with 60% HEFA
J50H50	blend of 50% Jet A-1 with 50% HEFA
PIV	particle image velocimetry
fps	frame per second
ms	millisecond
μm	micrometer
μs	microsecond

1.0 Introduction

Spray development and characteristics are essential for determining the combustion output of aircraft engines. The spray characteristics include cavitation, liquid breakup, atomisation and evaporation, all of