Spray and Combustion Analysis of n-Butanol/Diesel Blends under Spark-Assisted Compression Ignition (SACI) Engine

Warsita I Wayan [1)] · Ocktaeck Lim[*2)]

Graduate School of Mechanical Engineering, University of Ulsan, 93 Daehak-ro, Nam-gu, Ulsan 44610, South Korea[1)],
School of Mechanical Engineering, University of Ulsan, San 29, Mugeo2-dong, Nam-gu, Ulsan 44610, South Korea[2)]

Key words : N-butanol/diesel fuel blends, Spray characteristics, SACI, Combustion performance, Indicated thermal efficiency

* Corresponding author, E-mail: otlim@ulsan.ac.kr

This work examines how oxygenated biofuels, specifically long-chain alcohols, impact fuel atomization and combustion processes in compression ignition engines. The primary focus is assessing the influence of elevated n-butanol concentrations (70–90% by volume) mixed with diesel on spray development and combustion efficiency under varying operational conditions, employing a spark-assisted ignition technique. Experimental tests were conducted using a high-pressure constant volume chamber and a rapid compression-expansion apparatus to replicate realistic engine environments. Key performance indicators such as spray geometry, penetration distance, pressure trends, heat release patterns, and thermal efficiency were evaluated. Results indicate that increasing n-butanol content enhances spray propagation and dispersion at higher injection pressures without significantly altering the spray angle. The 90% blend exhibited the most notable variations compared to pure diesel. However, due to n-butanol's substantial cooling effect during vaporization, ignition delays increased. To address this, a controlled spark-assisted system was implemented, demonstrating improved combustion stability and higher peak pressures compared to conventional diesel operation. Ringing intensity measurements confirmed stable combustion across all tested blends, with values shows within acceptable limits of 5 MW/m². The study highlights the viability of high-ratio n-butanol-diesel mixtures when combined with spark-assisted strategies, offering a pathway for cleaner and efficient engine performance.

Acknowledgment:

- This result was supported by "Regional Innovation Strategy (RIS)" through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (MOE) (2021RIS-003)
- This work was supported by the National Research Foundation Korea (NRF) grant funded by the Korea government (MSIT) (No. RS-2023-00281590)