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Experimental Investigation of Higher Content n-Butanol on Diesel Fuel: Spray Dynamics and Combustion Performance with Spark-assisted Strategies

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]

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

This study explores the effects of oxygenated fuel, particularly long-chain alcohol fuel on diesel spray and combustion characteristics under compression ignition engine conditions. Among oxygenated fuels, n-butanol shows promise as an alternative fuel for diesel engines employing advanced combustion modes. The objective of this study is to investigate how the higher blend ratios of n-butanol on diesel fuel under various engine condition affect the spray dynamics and combustion characteristics. Experimental study was conducted in a constant volume chamber (CVC) and rapid compression-expansion machines (RCEM) specifically designed to emulate CI engine conditions, enabling a thorough assessment of how the inclusion of n-butanol influences spray behavior and combustion characteristics. The influence of n-butanol was analyzed by varying blending ratio of n-butanol from 70% to 90% with a 10% increment, assessing its effects on key parameters such as spray formation, cone angle, penetration length, combustion performance and efficiency. Additionally, experimental variables included varying injection pressure for the spray analysis, while start of injection (SOI) and spark duration were adjusted to evaluate their impact on combustion in the RCEM. The results reveal that increasing n-butanol content in diesel significantly influence spray and combustion performance. Changes in the physicochemical properties of the fuel alter spray formation and combustion characteristics. Notably, as the n-butanol content increases, spray tip penetration and the area of blended fuels also increases with higher injection pressure, while cone angle remains relatively unaffected. The 90% of n-butanol blends demonstrated the most pronounced differences compared to pure diesel. Furthermore, higher n-butanol proportions led to longer ignition delays and higher peak in-cylinder pressure. Longer spark duration time and retarding SOI up to 30 BTDC further contributed to higher peak in-cylinder pressure. The higher content of n-butanol up to 90% on diesel fuel demonstrated considerable potential for improving its spray and combustion characteristics, offering a chance to overcome the issues of traditional dual-fuel engines.

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