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Full Length Article

Experimental study on the combustion performance of a stationary CIDI engine fueled with 1-heptanol-diesel mixtures

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ABSTRACT

Because of its distinctive physicochemical properties, 1-heptanol has the potential to be widely used for fueling compression ignition direct injection (CIDI) engines. Its renewability also makes 1-heptanol an attractive option for this and other applications. In this study, we investigated the combustion of different 1-heptanol/diesel blends with up to 50 vol% 1-heptanol in a stationary CIDI engine under low injection pressure. The substitution ratios of 1-heptanol/diesel used were 10/90, 20/80, 30/70, 40/60, and 50/50 (v/v%), denoted in the text as Hep10, Hep20, Hep30, Hep40, and Hep50. This work utilized a one-cylinder naturally-aspirated air-cooled CIDI research engine. Steady-state tests were performed at various loads ranging from 10% to 100% and engine speeds between 900 and 1500 rpm. Our findings from the thermogravimetric experiment revealed that the 1-heptanol/diesel mixture evaporates faster than pure diesel. The 1-heptanol/diesel mixtures show longer ignition delay and are more likely to burn during the premixed combustion phase than diesel. Also, Hep10-50 blends release more heat in the premixed fast-burn mode, in contrast to regular diesel. Hep10-50 mixtures showed higher cyclic variation than diesel. The highest cyclic variation was for Hep30, with a COV_{imep} of 3.25%. At 75% load, compared to standard diesel, Hep50 showed a higher BTE and combustion efficiency by 1% and 3%, respectively, while the BSEC was lower than diesel by 5.8%. At 100% load, the peak cylinder pressure of Hep50 was higher than diesel by 3.8%, while the BTE and the combustion efficiency of Hep50 were lower than diesel by 2.5% and 2%. For engine loads of 10–75%, there were some improvements in engine performance for Hep10-50 mixtures compared to diesel, while a slight deterioration in engine performance was noted at 100% for Hep10-50 blends. For the Hep50 mixture, soot and NO_x emissions were reduced by 70% and 25%, respectively, compared to diesel.

1. Introduction

The widespread and long-established utilization of compression ignition (CI) engines in passenger cars, railway locomotives, goods vehicles, and various industrial-agricultural sectors is due to their high efficiency and superior fuel economy [1,2]. Nevertheless, excess soot and NO_x formation is a major drawback of CI engines, particularly with the increasingly stringent emissions legislations that have been introduced in recent years [3,4]. Besides, the depletion of fossil fuels is another issue that has intensified the search for a replacement for conventional fuels [5–8]. Biofuels, particularly alcohols, have helped researchers to develop new engine technologies such as reactivity-controlled compression ignition (RCCI) engines [9,10]. Therefore, research has focused on alcohols and their usage in CI engines to improve engine control, enhance soot oxidation, reduce NO_x emissions, and reduce the dependence on diesel oil [11–13].

Higher alcohols (long-chained molecular structure alcohols), such as the C_4-C_8 alcohols, are gaining more attention because they possess several benefits compared to lower alcohols (short-chained molecular structure alcohols) such as methanol and ethanol [14–16]. Higher alcohols possess higher energy content and boiling points, which are less sensitive to water with a lower oxygen content, and are less corrosive, to form more stable mixtures with diesel than lower alcohols [17,18]. Therefore, higher alcohols can fuel CI engines without any adjustments to the engine required [19,20]. Especially when they can be produced biologically like ethanol [21–23], higher alcohols have the potential to be the next-generation alternative fuel for compression ignition direct injection (CIDI) engines [24,25]. While butanol and pentanol have been

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