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Improvement of CI engine combustion and performance running on ternary blends of higher alcohol (Pentanol and Octanol)/hydrous ethanol/diesel

Mohamed Nour[a,*], Ali M.A. Attia[a,b], Sameh A. Nada[a,c]

[a] Mechanical Engineering Department, Benha Faculty of Engineering, Banha University, Benha, Egypt
[b] Department of Mechanical Engineering, College of Engineering, University of Bisha, Bisha, Saudi Arabia
[c] Egypt-Japan University of Science and Technology, New Borg El-Arab City, Alexandria, Egypt

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ABSTRACT

Pentanol and Octanol are strong candidates to improve the blending stability of hydrous ethanol and diesel. Most of the available studies are limited to the stability assessment and properties characterization without combustion evaluation. In this study, the impact of ternary blends of pentanol/hydrous ethanol/diesel (Pe10E10D80) and octanol/hydrous ethanol/diesel (Oc10E10D80) on CI engine combustion and performance are investigated. The fuel characteristics are measured, and a thermogravimetric analysis is performed. A set of experiments are performed on a CI engine at a wide range of operating conditions. The experiments report that the peak cylinder pressures for Pe10E10D80 and Oc10E10D80 are lower than that of D100. The rate of heat release (RoHR) at premixed combustion phase is diminished but enhanced for diffusion combustion zone. Ignition delay and combustion duration increased for ternary blends. The BSEC and bsfc for Oc10E10D80 is lower than D100, but both for Pe10E10D80 are higher than D100. The BTE of Oc10E10D80 is higher than D100, but Pe10E10D80 has lower BTE. The smoke, NO_x, CO and CO_2 emissions are reduced by 73%, 33%, 83%, and 56%, respectively. Pentanol and octanol addition to hydrous ethanol/diesel blend achieves better blending stability with improved engine performance and reduced emissions.

1. Introduction

Over many decades, fossil fuels have been used to power transportation. The transition to a sustainable energy system can be accelerated by investing in biofuels. Ethanol is an important biofuel that has been studied extensively as an alternative fuel for CI engines [1]. Ethanol can be produced through fermentation of lignocellulose waste that found to be cheap and clean method [2,3]. However, a large percentage of energy used in ethanol production is dissipated in dehydration particularly when ethanol purity is higher than 80% [4]. Therefore, the usage of hydrous ethanol directly has a great cost significance.

Researchers found that the usage of hydrous ethanol in the CI engines has many advantages. Hydrous ethanol contains high oxygen contents compared to diesel fuel. The high oxygen contents of the ethanol and the existence of hydroxyl group (OH) enhance soot oxidation and reduce particulate matter (PM) [5]. The water also decreases the flame temperature and consequently, thermal NO_x decreased. Additionally, the micro-explosion of water within the fuel droplet promotes the fuel break-up and enhances air-fuel mixing, diminishing the localized rich regions [6]. Also, ethanol is safe for fuel handling and storage due to that the minimum auto-ignition temperature of ethanol is 423 °C which is higher than those of conventional fuels [7].

On the other hand, the existence of water in diesel/ethanol blends causes phase separation and miscibility problems [8]. This is due to that presence of water enhances the polarity of the OH group in ethanol, consequently, the diesel which is non-polar molecule could not be miscible with hydrous ethanol at any blending ratio at the low ambient temperatures [8–10]. Also, water carries contaminants into the fuel storage tank, which is designed for diesel fuel. Additionally, ethanol has a low calorific value, a high latent heat of vaporization and low cetane number of 26900 kJ/kg, 850 kJ/kg and 8 respectively, compared to 43500 kJ/kg, 270 kJ/kg and 49 for diesel. It can be concluded that ethanol is not the perfect fuel for CI engines.

To avoid phase separation and miscibility problems, researchers used two techniques either by ethanol fumigation in the intake air or ethanol-diesel dual fuel RCCI mode. The tested energetic fractions of ethanol were up to 63% [11]. However, the high energetic fractions of ethanol are not recommended due to either the insufficient ignition energy or high knock tendency. The addition of hydrous ethanol to diesel increases the ignition delay and enhanced premixed combustion

* Corresponding author.
E-mail address: mohamed.nour@bhit.bu.edu.eg (M. Nour).

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