Energy 168 (2019) 136–150

Contents lists available at ScienceDirect

Energy

journal homepage: www.elsevier.com/locate/energy

Modeling and experimental investigation for performance and emissions on a diesel engine using bio-oxygenated ternary fuel blends

Ashish Nayyar [a,*], Dilip Sharma [b], Shyam Lal Soni [b], Bhuvnesh Bhardwaj [c], Manu Augustine [a]

[a] Department of Mechanical Engineering, Swami Keshvanand Institute of Technology, Management & Gramothan, Jaipur, 302017, India
[b] Department of Mechanical Engineering, Malaviya National Institute of Technology, Jaipur, 302017, India
[c] Department of Mechanical Engineering, JECRC, Jaipur, India

ARTICLE INFO

Article history:
Received 9 April 2018
Received in revised form
18 September 2018
Accepted 22 November 2018
Available online 24 November 2018

Keywords:
Emission
Diesel
Blend
Smoke
Additives
Bio-oxygenated

ABSTRACT

The increasing cost of fossil fuels as well as increasing environmental pollution has attracted research in alternative fuels and additives for improving the performance and reducing emissions of diesel engines without costly engine modifications. In the present article, an exhaustive analysis of the performance and emissions of oxygenated ternary fuel blends is done through modeling and experimental investigation to determine the optimal blending ratio of additives for reduced emissions. The Nitromethane-n-butanol–diesel blend is termed as bio-oxygenated fuel. Baseline data were generated by using diesel and a blend of 20% (v/v) n-butanol with diesel (B20). Ternary blends of Nitromethane (NM) and B20 containing 1–3% NM by volume were prepared and experiments were conducted. It was observed that 1% of Nitromethane by volume (NM1B20) gives best results for emission reduction. The overall effect of this ternary blend was reduction in smoke and nitrogen oxides (NO_x) by 61.85% and 8.07%, respectively, as compared to diesel. Moreover, the performance of ternary blend was also found to be better than the base fuels. It was thus concluded that Nitromethane-n-butanol–diesel blends can be highly effective alternatives in reducing emissions in diesel engines with a little improvement in the overall performance characteristics.

1. Introduction

The versatile diesel engine is ubiquitous in transportation and power generation applications. The increasing cost of fossil fuels and growing environmental concerns during the past few decades have attracted many researchers towards issues pertaining to alternative fuels and additives for improving performance and emissions without costly engine modifications [1–3].

It has been reported in literature that combustion improves with increasing percentage of oxygenated fuel in a blend. Alcohols are oxygenated fuels; the presence of oxygen in their molecular structure and higher volatility renders them compatible for blending with diesel [4–8].

The properties of n-butanol are very similar to that of fossil fuels. As compared to methanol and ethanol, it has a higher Cetane number, higher heating value, is less corrosive, has more calorific value and is more miscible in diesel [9–11]. N-butanol is mainly produced as a biofuel. This fact further enhances its appeal in comparison to other alternative fuels. Butanol blending up to 5% (v/v) has been found to be very effective in reducing the emissions of smoke and NO_x [12,13]. The blending of butanol (10% v/v) with vegetable oil–diesel (20:70) blends results in decreased CO_2 and HC and increased BSFC, NO_x and CO. However, the variation of HC and CO is further dependent on vegetable oil properties [14,15]. Substitution of 10% n-butanol was found to have resulted in reduction of NO_x and PM emissions at the cost of engine performance [16,17].

Experimental studies have been conducted on diesel engines at steady-state conditions with 8–24% (v/v) n-butanol-diesel and

Abbreviations: BTE, Brake thermal efficiency; BSFC, Brake specific fuel consumption; BSEC, Brake specific energy consumption; CI, Compression ignition; CN, Cetane number; CO, Carbon monoxide; CO_2, Carbon dioxide; CR, Compression ratio; DI, Direct injection; HC, Hydrocarbon; IC, Internal combustion; NM, Nitromethane; NO_x, Nitrogen oxides; PM, Particulate matter; v/v, volume/volume.

* Corresponding author.
E-mail addresses: ashishnayyar@skit.ac.in (A. Nayyar), sharmadmnit@gmail.com (D. Sharma), shyamlalsoni@gmail.com (S.L. Soni), bhuvnesh.bhardwaj@gmail.com (B. Bhardwaj), augustine.manu@gmail.com (M. Augustine).

https://doi.org/10.1016/j.energy.2018.11.098
0360-5442/