Transportation Research Part D 53 (2017) 403–414

Contents lists available at ScienceDirect

Transportation Research Part D

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

Exhaust emissions of biodiesel binary and multi-blends from Cotton, Jatropha and Neem oil from stationary multi cylinder CI engine

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ARTICLE INFO

Article history:
Available online 6 May 2017

Keywords:
Biodiesel
Binary blends
Combustion
Multi-blends
Emissions
Cotton
Jatropha
Neem

ABSTRACT

Biodiesel considerably decrease the CO and CO_2 emissions and its blends reduce NO_X emissions. In this work, binary blends of biodiesel from Cotton, Jatropha and Neem with diesel were prepared in form of B5C, B10C, B15C, B20C, B25C and B30C for Cotton at 5%, 10%, 15%, 20%, 25% and 30% respectively. This was similarly done for Jatropha and Neem biodiesel designated as B5J and B10N, etc. A set of multi-blends of all the 3biodiesel with diesel were also prepared. The fuel samples were used to run a Cusson's 4-cylinder, stationary diesel engine with data logger system. The exhaust emissions of fuel during the combustion process were measured using IMR 1400 gas analyser to detect the composition of flue gases at 1500 rpm, 2000 rpm, and 2500 rpm engine speeds. It was found that, B20C has the lowest exhaust temperature, lowest percentage losses, highest combustion efficiency, and lowest NO_X and CO_2 emissions, but highest SO_2 emissions although with negligible percentage. The binary biodiesel blends are better than the multi-blends in terms of exhaust emissions reduction.

1. Introduction

Biodiesel is an oxygenated fuel; consequently it yields a complete combustion which produces exceptional emission properties and generates less negative environmental effects. Different investigations were carried out on engine emission characteristics on non-edible biodiesels (Ashraful et al., 2014). Engine working condition and biodiesel fraction in the blend expressively upset engine emission physiognomies. Research and investigations show that there is high carbon monoxide and Nitrogen oxides (CO and NO_X) emission in the combustion of diesel fuels in compression ignition (CI) engine (Atabani et al., 2013a, 2013b). It has been established in the literature that biodiesel considerably decreases the CO and CO_2 emission but gives a little higher NO_X emission. It was verified that NO_X can be reduced by some approach such as blending the biodiesel with additives and engine gas reticulation (EGR) methods (Mofijur et al., 2014a, 2014b). Presently, alternate fuels are being studied intensively for use in compression ignition (CI) engines consequential in exciting future prospects to increase energy security and reduce gas emissions. Biodiesel is one of the substitute fuels which is renewable, sustainable and ecologically friendly and can be utilised in diesel engines with little or no modifications (Nabi and Hustad, 2010). Carbon dioxide (CO_2) is one of the gases emitted during combustion of carbon in fuel. There is no universal consensus on the effect of

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http://dx.doi.org/10.1016/j.trd.2017.04.040
1361-9209/

biodiesel on the emission of CO_2 from CI engines. Some authors have reported that when a CI engine runs with biodiesel, the CO_2 emission increases as compared to petrol-diesel (Ramadhas et al., 2013). Researchers have reported that CO_2 emission increases when the engine is running with biodiesel, while 38.5% of the researchers have reported the reverse trend, and 15.4% of the researchers have reported that engines running with diesel and biodiesel have similar emissions (Tesfa et al., 2013). The CO_2 trend discrepancy may be happening due to the variation of biodiesel feedstock sources, engine types and testing procedures (Tesfa et al., 2013). The incomplete combustion of fossil fuels and fuel evaporation from the open areas are the major sources of hydrocarbons (HC) in the atmosphere. Most reviewed literatures show a sharp decrease in the THC emissions when substituting conventional diesel fuel with biodiesel fuels in engines due to oxygen, which provides more complete combustion (Fontaras et al., 2009).

However, despite the contributions made by so many researchers on the subject matter, there is a particular gap in the area of determination of exhaust emissions of the multi-blends. This article therefore, has considered the binary blends of Jatropha, Cotton, and Neem biodiesel with diesel. The article explained how different blend ratios of biodiesel from the three feedstocks were mixed with diesel in binary and ternary form. Also, research investigated the effects of these blend ratios on exhaust emissions in a four cylinder compression ignition engine. This approach is not common amongst the researchers working on the subject matter. Most of the recent researches consider the exhaust emissions of a single binary biodiesel blend in a stationary single cylinder diesel engine. Ashraful et al. (2014) has worked on Production and comparison of fuel properties, engine performance, and emission characteristics of biodiesel from various non-edible vegetable oils. Atabani et al. (2013a, 2013b), Mofijur et al. (2014a, 2014b), Mofijur et al. (2013a, 2013b), Mofijur et al. (2015), Mosarof et al. (2016) have also worked on the engine performance and emissions of different biodiesel feedstocks, but none of the cited authors has considered the ternary blends. In this research, the use of IMR 1400 exhaust gas analyser to determine flue gases during the combustion of binary and multi-blends of diesel from stationary four cylinder diesel engine has been thoroughly investigated. The issue of variation of different biodiesel blends ratios with exhaust emissions at different engine speeds are dealt with in this work. The idea is to project the possibility of reducing green house gases emissions in the transport sector. Heavy duty diesel engines used for commercial and mass transit transportation produce tremendous emissions. The idea of using biodiesel as part substitute to diesel in compression ignition engines to lower greenhouse gases emissions during the combustion of fossil diesel is hereby promoted by this research. The objective of this research is to investigate the exhaust gas emissions during the combustion of biodiesels from cotton, Jatropha and Neem, and their binary and multi-blends with diesel in stationary multi cylinder CI engine.

2. Methodology

2.1. Sample preparation

The blending has been carried out for each biodiesel type with the petroleum diesel alone, and that of a mixed biodiesel samples (Fractional Blends or Multi Blends) with pure petroleum diesel. Each biodiesel sample has been blended with fossil diesel in a ratio of 5:95, 10:90, 15:85 and 20:80, 25:75 and 30:70 and a pure sample of each biodiesel as well as a pure petro-diesel sample kept for control purpose denoted as B5, B10, B15, B20, B25, B30, B50 and B100 for the biodiesel blends and B0 for the pure petroleum diesel respectively.

Furthermore, a mixed samples of all biodiesel with the fossil diesel have been mixed together to form fractional/multi blends with B(2:2:2), B(3:3:3), B(4:4:4) B(5:5:5) and B(10:10:10) meaning 2% of each of the 3 samples in 94% diesel, 3% of each of the 3 samples in 91% diesel, 4% of each of the 3 samples in 88% diesel, 5% of each of the 3 samples in 85% diesel and 10% of each of the 3 samples in 70% diesel mixed together respectively. Finally, the samples of the pure petro diesel, 100% biodiesels from Cotton, Jatropha and Neem seed was kept as controlled samples labeled as B0, B100c, B100j and B100n respectively.

The binary blends of Cotton Seed alone with diesel were labeled B5c, B10c, B15c, B20c, B25c and B30c. The binary blends of Jatropha alone have been labeled B5j, B10j, B15j, B20j, B25j and B30j. The binary blends of Neem seed and petro-diesel alone also labeled B5n, B10n, B15n, B20n, B25n and B30n correspondingly. Ultimately, the multi-blends of Cotton, Jatropha and Neem seed biodiesel with petro-diesel have the labeled B2:2:2, B3:3:3, B4:4:4, B5:5:5 and B10:10:10 in that order. We kept the samples for further analyses.

2.2. The engine operations

This study has been conducted to investigate the emission characteristics of a stationary four cylinder diesel engine run on different bio-diesel/petro diesel blends and also on diesel fuel alone. The engine test has been carried out under full loading conditions at varying speeds conditions of 1500 rpm, 2000 rpm and 2500 rpm for each of the blends. The engine specifications are presented in Table 1 below.

2.3. Exhaust gas analyses

The combustion gases has been analysed using the IMR 1400 combustion gas analyser, 2014 model, manufactured by Environmental Equipment Incorporation, Central Avenue, St. Petersburg, Florida, USA available in the Department of