Renewable and Sustainable Energy Reviews 92 (2018) 38–49

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

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

A review on biodiesel production, combustion, performance, and emission characteristics of non-edible oils in variable compression ratio diesel engine using biodiesel and its blends

M. Suresh, C.P. Jawahar*, Arun Richard

Department of Mechanical Engineering, Karunya University, Coimbatore, India

ARTICLE INFO

Keywords:
Biodiesel
Blending
Emission
Non-edible oil
Variable compression ratio
Transesterification

ABSTRACT

The dwindling of natural resources such as crude oil, coal etc. has made it essential to switch over to biodiesel. Biodiesel has a number of properties which are beneficial to the environment. The main advantage of biodiesel is that it's carbon neutral and it does not create carbon dioxide (CO_2). In addition, it leads to a decrease in pollution by reducing the emission of harmful and hazardous substances to the atmosphere and greatly improves the engine performance. This paper puts forward a comprehensive assessment of biodiesel production from various non-edible oils such as waste fried oil, pyrolysis oil, preheated palm oil, waste cooking oil, jatropha oil, karanja oil etc. It also serves as an index to measure combustion, performance and emission characteristics in a variable compression ratio (VCR) diesel engine, where biodiesel is blended with diesel. The need for switching over to VCR engine is that it provides better fuel efficiency, up to 30% reduction in fuel consumption, better control at peak cylinder pressure, ability to use multi-fuel and reduction in the exhaust emissions when compared to that of a constant compression ratio diesel engine.

1. Introduction

The natural resources in the world have a wide range of application in the field of science and technology. Some of the natural resources such as coal, crude oil and so forth are employed in power plants, boilers, and some automotive engines. But they are getting exhausted day-by-day due to the increasing demand for these natural resources. In India, the energy demand increases at a rate of 6.5% per annum [1], while the crude oil demand of the country that is met by imports is about 80%. Therefore, energy security becomes a key issue for the nation as a whole [2,3]. Also, there is a huge amount of pollution in the atmosphere due to the burning of these natural resources. Hence, it has become essential to transition towards alternate fuels. Nowadays, the utilization of biodiesel is gaining popularity as it is a clean fuel produced from domestic and renewable resources. Biodiesel can be blended in any proportion with diesel to obtain a biodiesel blend [4,5]. It's more environment-friendly and non-toxic than ordinary diesel [6–8] and when blended with diesel, improves the mechanical efficiency of engines. Usage of biodiesel in the engine will reduce emissions of sulphur dioxide (SO_2), which is the primary cause of acid rain. It has high lubrication properties which improves the life and the performance of the engine. Safety of operation is also improved due to it's high flash point. Working with biodiesel is safer than working with diesel and it can be used in engines without any modifications [9,10]. Numerous car manufacturers like Massey-Ferguson, Passage, John Deere, Volkswagen, Mercedes, Volvo, BMW etc have acknowledged the fact that biodiesel is a fuel that is compatible with their current line of diesel vehicles [11,12]. The disadvantage is that the price of biodiesel is quite high and availability is less. It also decreases the fuel economy and increases the exhaust emissions [13,14].

It has been inferred from the review of literature that an extensive research has been conducted on diesel engines with a constant compression ratio using diesel, bio-diesel or its blends. There has not been any work reported in the literature pertaining to review of the

Abbreviations: ASTM, American Society for Testing and Materials; BMEP, Brake Mean Effective Pressure; BSHC, Brake Specific Hydrocarbon Emission; BTE, Brake Thermal Efficiency; CA, Crank Angle (°); CAT, Catalyst; CCR, Constant Compression Ratio; COSME, Cotton Seed Oil Methyl Ester; DFDE, Dual Fuel Diesel Engine; DI, Direct Injection; EGT, Exhaust Gas Temperature; EP, Engine Performance; FAME, Fatty Acid Methyl Ester; FFA, Free Fatty Acid; GLY, Glycerol; HC, Hydrocarbon; HRR, heat release rate; HSD, High Speed Diesel; SA, Sulphuric Acid; KOH, Potassium Hydroxide; KNO_3, Potassium Nitrate; LME, Linseed Methyl Ester; MeOH, Methanol; NaOH, Sodium Hydroxide; NO_X, Oxides of Nitrogen; OCR, Optimum Compression Ratio; O_2, Oxygen; PM, Particulate Matter; PPM, Parts Per Million; RPM, Revolutions Per Minute; RSO, Rubber Seed Oil; SO_2, Sulphur Dioxide; SME, Sunflower Methyl Ester; TPSO, Thevetia peruviana Seed Oil; VCR, Variable Compression Ratio; WFOME, Waste Fried Oil Methyl Ester; WPO, Waste Plastic Oil

* Corresponding author.
E-mail addresses: thillaisuresh@gmail.com (M. Suresh), cpjawahar@gmail.com (C.P. Jawahar).

https://doi.org/10.1016/j.rser.2018.04.048
Received 14 April 2017; Received in revised form 30 March 2018; Accepted 14 April 2018
1364-0321/ © 2018 Elsevier Ltd. All rights reserved.

drawback of using biodiesel at constant compression ratio. Hence, this paper discusses the performance tests conducted on various forms of engines that run on biodiesel extracted from different types of non-edible oils. The influence of various parameters like combustion characteristics and performance of the engine on emission characteristics are also discussed. This is based on the results of previous researchers using VCR engine with direct fuel injection.

The various outcomes, while using biodiesel and it's blends as main sources of fuel have been compared and summarized.

2. Biodiesel production

Singh et al. [15] produced biodiesel from non-edible feed stock, such as karanja and mahua along with hybrid varieties (50:50 by volume) of the two. A dual-step reaction in which esterification of acid that decreased the amount of free fatty acid (FFA) to the desired limit was followed by alkaline transesterification process. This was done to convert oils to fatty acids of methyl esters. To support the esterification reaction, sulphuric acid was being used as the catalyst. The transesterification process involved the addition of potassium hydroxide (KOH) and Methanol as the catalysts. Methanol can be stated as an alcohol which lowers the reaction time while it's inexpensive.

Fen Guo and Li-Qun Jiang [16] produced biodiesel from jatropha oil with superior acid charge in ionic liquids and observed a maximum yield of 99.7%. Ma and Hanna [17] also observed that biodiesel could be obtained by blending, micro emulsions, thermal cracking (pyrolysis) and transesterification. Base catalysts were much more preferable and reasonable than corrosive enzymes and catalysts. An advised amount of base to be utilized was somewhere around 0.10% and 1% w/w of oils and fats. Kobayashi Genta et al. [18] observed that the amount of catalyst, the ratio of methanol to oil in moles and the temperature of reaction on the yield of the acid-catalyzed production were the significant factors in methyl ester production (biodiesel) from crude palm oil. McLean et al. [19] employed acid-catalyzed transesterification process to produce biodiesel, because the percentage of free fatty acids in the oils or fats was high. A molar ratio of (as high as) 15:1 was required for processing waste cooking oil. Juan et al. [20] utilized catalytic and non-catalytic methods to produce biodiesel from jatropha. They concluded that an alkaline catalyst and a two-step transesterification process were more suitable for biodiesel production if the FFA content in the jatropha oil was less than 1% and more than 1% respectively. Man et al. [21] studied the two reaction step process which was used in this process, a batch reactor simultaneously synthesized beef tallow Ester (BTE), canola methyl ester (CME), linseed methyl ester (LME), rapeseed methyl Ester (RME) and sunflower methyl ester (SME) while using catalysts such as NaOH, KOH, and sodium meth oxide. Ghadge and Raheman [22] observed that high free fatty acid content was available in the production of biodiesel from the Mahua Indica oil. And also, the raw material could be synthesized by processes such as blending, pyrolysis, transesterification. Reddy et al. [23] produced biodiesel by using a three-stage transesterification process in which methanol was used. The acid esterification was carried out with a catalyst such as sulphuric acid H_2SO_4 and the alkali transesterification was done with KOH acting as the catalyst. The product was then gently washed three times using distilled water. Sam Chelladurai et al. [24] examined the biodiesel production from crude Jatropha curcas oil for transesterification process using one pace alkali catalyst. They observed the various biodiesel yields at different molar ratios like 5.5:1, 6:1, 6.75:1, 7.5:1, and 8:1. They recorded varied response temperature from 50 °C to 70 °C. A maximum yield of 80.5 was attained. They found that the yield was low due to the higher fatty acid content in crude Jatropha curcas oil. They also observed that the kinematic viscosity was reduced after transesterification process and the different properties were found to be according to the American Society for Testing Materials (ASTM) specifications. Das and Naik [25] studied the preparation of non-edible oils like jatropha (Jatropha curcas), karanja (Pongamia Pinnata) and polanga (Calophyllum inophyllum) oil-based methyl esters which were mixed with conservative diesel devising Sulphur content less than 10 mg/kg. Idalina Raposo et al. [26] produced biodiesel using frying oils by transesterification process. The results showed that after an hour of reaction, methanol/waste frying oil proportion was 4.8. For effective viscosity reduction and to increase the purity of the layer, a catalyst (KOH)/ waste frying oil with a weight proportion of about 0. 6% which provides for yielding methyl esters was added. Irfan et al. [27] investigated the two-stage transesterification method for converting waste oil into biodiesel. They reported a maximum biodiesel yield of 85.5% (methyl ester of eatery waste oil) at the optimum condition. Alamu et al. [28] utilized Palm kernel oil (PKO) with ethanol and NaOH as catalyst to produce biodiesel. The transesterification process was carried out using 100 g PKO, 0–20 kg ethanol, 1% NaOH reaction temperature and 90 min' reaction time which produced 95.8 g of PKO biodiesel. Higher specific gravity, mist and pour points were attained compared to that of gasoline diesel.

Errazu et al. [29] demonstrated various methods of producing biodiesel such as the alkyl catalyzed reaction process had higher return compared to the acid catalyzed reaction. The time required for the reaction was found to be lower for alkyl catalyzed reaction compared to the corrosive catalyzed reaction. However, the recovery of glycerol was tough in case of alkyl catalyzed reaction. Canola methyl ester (CME), Rapeseed methyl ester (RME), and Sunflower (SME) were synthesized in a batch reactor using NaOH, KOH, and $NaOCH_3$ as catalysts. Pramanik et al. [30] analyzed and compared the mixtures of Jatropha curcas oil biodiesel diesel. The effect of heat on the viscosity of biodiesel and jatropha oil was also determined. Nurun Nabi and Shamim Akhter [31] studied the production of biodiesel and the choice of cottonseed oil (CSO) to be used. A biodiesel production percentage of 77% was achieved with 20% methanol and a trace presence of 0.5% sodium hydroxide. Madhumita Verma et al. [32] analyzed biodiesel production from karanja oil by transesterification method. Physical and chemical assets of the Karanja oil and that of the methyl ester were determined. Noor Aishah Saidina Amin and Hossein Mazaheri [33] examined the use of different catalyzed transesterification reactions for the manufacture of biodiesel. Briefly, the effect of different procedures like reactive distillation pillar, a membrane reactor, reactive absorption, microwave irradiation and ultrasonic, significantly influenced the final conversion, and in particular, the yield and eminence of the product.

Saka et al. [34] attempted to cover a variety of possible methods in biodiesel production from waste/useless cookery oil. The effect of water on the production of biodiesel fuel by supercritical methanol treatment was also studied. Jayaraj et al. [35] analyzed biodiesel production from rubber seed oil with high free fatty acid content. A two-step transesterification method was developed to get mono-esters by the conversion of high free carboxylic acid oils. Raheman et al. [36] examined the biodiesel preparation with the use of response surface methodology, to prepare the biodiesel fuel from high free fatty acid oils. Physical and chemical assets of the rubber seed oil and that of the methyl ester had been determined. Altun et al. [37] produced biodiesel using a base-catalyzed transesterification of inedible animal tallow with NaOH and Methanol as catalyst and found that the time taken for the reaction and temperature affected the quantity and quality of esters. Deng et al. [38] investigated biodiesel production from unprocessed Jatropha curcas and karanja oil using acid esterification and alkali transesterification. The acid esterification was done with methanol using H_2SO_4 as a catalyst. Alkali transesterification was done with KOH as catalyst. Ikwuagwu et al. [39] reported that rubber seed oil biodiesel has fuel properties closer to that of diesel, except slightly higher viscosity. The outcomes supported the choice of monosters, in place of straight rubber seed oil, as having enhanced potential for use as alternative diesel fuel. However, the oxidative stability was reduced by trans-methylation.

Sukumar Puhan et al. [40] investigated mahua oil ethyl ester by transesterification using sulphuric acid (H_2SO_4) as a catalyst and verified it in a 4-stroke direct injection diesel engine. Sreenatha Reddy

Download English Version:

https://daneshyari.com/en/article/8110828

Download Persian Version:

https://daneshyari.com/article/8110828

Daneshyari.com