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Effects of injection timing on bio-diesel fuelled engine characteristics—An overview

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ABSTRACT

In day to day life, we are in need of alternative fuel to create an eco-friendly environment and also to meet out the increasing energy consumption rates. The specific characteristics such as renewability, sustainability and clean burning capacity put ahead the bio-diesels as one among the best choice for alternative fuels. Though there are several ideas and technologies to confront the challenges, they are often confined to a distant future, especially with regard to C.I engines. This review depicts how straight vegetable oil affects the fuel injection nozzle, ring sticking, dilution of the lubricating oil. Also, the different techniques of biodiesel production from straight vegetable oil (SVO) are included. The variables affecting the transesterification reaction, advantages, disadvantages of different types of bio-diesel productions and properties are discussed. The distinct factors of performance and emissions decide the use of fuels in engines. A brief discussion is made on the performance, emission and combustion characteristics of various bio-diesel sources like edible oil, inedible oil, and waste plastic oil. This paper goes on to talk of the advance, retardation methods to treat NO_x, HC and CO, and finally a comparative evaluation has been made on coated and uncoated engines with thermal barrier. The energy study for cost of plantation of nonedible oil seeds and cost of bio-diesel production are also discussed.

1. Introduction

As the fossil fuels are getting depleted day by day, the urge for an alternative fuel to fulfill the energy demands of the world is also increasing. Bio-diesel is one of the best available sources to fulfill the energy demands of the world. Though the petroleum fuels play a very important role in the development of industrial growth, transportation, agricultural sector and to meet many other basic human needs, these fuels are limited and depleting day by day as the consumption is increasing rapidly. Moreover, its usage is alarming and it causes a lot of environmental problems to the society (i.e.) burning of the fossil fuel which releases smog and greenhouse gases that contribute to global warming. Bio-diesel is gaining more importance as an alternative fuel to meet out the energy demands of the society [1].

The feedstocks used at present in commercial bioethanol production are sugar cane (Brazil) and maize (US). The use of first generation feedstock's for fuel production is associated with several issues that include the impact on food prices as demand for crops increases the competition between the use of crops for fuel production and for food supply as the world population is anticipated to increase from 6.5 billion to 9 billion by 2050. Tables 1.1 and 1.2 show future expected population. It clearly shows India will stand a first in terms of population [2]. Fossil fuels emissions are major contributors to greenhouse gases, which may lead to global warming. Combustion from fossil fuels is a major source of air pollutants which consist of CO, NO_x, SO_x, HC, particulates matter and carcinogenic compounds [3].

The name bio-diesel was introduced in the United States during 1992 by the National soy diesel Development Board (presently national bio-diesel board) which has pioneered the commercialization of bio-diesel in the United States. Bio-diesel can be used in any ratio with petroleum diesel as it has very similar characteristics but it has lower exhaust emissions. Bio-diesel has better fuel properties than that of petroleum diesel such as renewability, biodegradability, nontoxic, and free of sulfur and aromatics [4]. Usually, coconut, sesame, rapeseed, corn, palm and soybean are the present feedstock for bio-diesel

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Table 1.1
Top ten largest countries and their populations, selected years 1950 to 2050 in millions.

Rank	Country	Population in millions up to 1950 year	Rank	Country	Population in millions up to 2000 year	Rank	Country	Population in millions up to 2050 year
1	China	554.8	1	China	1275.2	1	India	1531.4
2	India	357.6	2	India	1016.9	2	China	1395.2
3	U.S.A	157.8	3	U.S.A	285.0	3	U.S.A	408.7
4	Russian	102.7	4	Indonesia	211.6	4	Pakistan	348.7
5	Japan	83.6	5	Brazil	171.8	5	Indonesia	293.8
6	Indonesia	79.5	6	Russian	145.6	6	Nigeria	258.5
7	Germany	68.4	7	Pakistan	142.7	7	Bangladesh	254.6
8	Brazil	54.0	8	Bangladesh	138.8	8	Brazil	233.1
9	United kingdom	49.8	9	Japan	127.0	9	Ethiopia	171.0
10	Italy	47.1	10	Nigeria	114.7	10	Congo, DR	151.6

Table 1.2
Top ten largest countries and their populations, selected years 2100 to 2300 in millions.

Rank	Country	Population in millions up to 2100 year	Rank	Country	Population in millions up to 2200 year	Rank	Country	Population in millions up to 2300 year
1	India	1458.4	1	India	1304.5	1	India	1371.7
2	China	1181.5	2	China	1200.7	2	China	1285.7
3	U.S.A	437.2	3	U.S.A	470.0	3	U.S.A	493.0
4	Pakistan	408.5	4	Pakistan	342.5	4	Pakistan	359.1
5	Nigeria	302.5	5	Nigeria	268.4	5	Nigeria	282.8
6	Indonesia	272.8	6	Indonesia	263.0	6	Indonesia	276.2
7	Bangladesh	259.9	7	Bangladesh	232.0	7	Bangladesh	242.7
8	Ethiopia	222.2	8	Brazil	208.8	8	Brazil	222.6
9	Brazil	212.4	9	Ethiopia	196.9	9	Ethiopia	206.5
10	Congo, DR	203.3	10	Congo, DR	173.0	10	Congo, DR	182.7

production because they are edible oils. The high value of edible vegetable oils as a food product makes production of bio-diesel fuel very challenging as a cost of raw material accounts for 60–70% of the total production cost of biodiesel fuel [5].

2. Impacts of diesel fuel and bio-diesel

2.1. Demand for diesel and bio-diesel

Diesel fuel is used in different sectors like industries, agriculture and transportation. As the demand of the diesel fuel increases, the price of the fuel also keeps on increasing which becomes a great setback for the economy of India. Increasing diesel and bio-diesel demand year by year has been reported [6] and indicated in Figs. 1.1. and 1.2. The usage of automobiles increases with exponentially increasing population. So the requirement of fossil fuel is also increasing rapidly.

To resolve the emission problem from fossil fuel and to find the viable alternative fuel likely to persist in foreseeable future, this study focuses on the use of SVO which is converted in to bio-diesel, because it is environment friendly. The SVO offers potential, environmental advantages provided that various technical criteria also can be met. Previous reviewers in this area collected the engine performance with different types of blends and exhaust emission results are presented with the aim of investigating the potential of non-edible oils are fuel for C.I. engines. The objective of this study is to review the performance and emission characteristics of vegetable oil and the methodology of converting vegetable oil into bio-diesel. Performance, emission, and combustion characteristics of biodiesel and diesel blends with standard and advanced injection timing and also characteristics of low heat rejection engine operated with bio-fuels are presented. We also set out to provide a more comprehensive and up to date study covering both technical and environmental issues.

2.2. Vegetables oil

The unprocessed vegetable oil can also be used in diesel engine with required adjustment in the engine driving habits. Unlike vegetable oil contains mostly of saturated hydrocarbons and those vegetable oil are triglycerides consisting of glycerol esters of fatty acids. Vegetable oils have different chemical structures up to three fatty acids linked in a glycerol molecules with ester linkage. The fatty acid varies in the carbon chain length and its number of double bonds. Some of the fatty acids and their chemical name, structural and formula are listed in Table 2.1. Higher structure of fatty acids in oil gives a higher cetane number and the oil is less prone to oxidation, due to its high percentage of saturated fatty acid and free fatty acids [7,8].

2.3. Problems for using vegetable oils in CI engines

It has been found that natural vegetable oil can be used as a substitute for diesel fuel in conventional diesel engine but it leads to the following problems, because mainly it contains water, phospholipids, odorants, sterols, and other impurities.

- The high flash point attributes to lower volatility.
- High viscosity of vegetable oil interferes with the injection process and leads to poor atomization.
- Injection nozzle failure.
- The inefficient mixing of fuel air contributes to incomplete combustion, leading to heavy smoke emission.