Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2016, 8(11):192-198

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

A Review on Influence of LHR Application on CI Engine Characteristics with Vegetable Oil Biodiesel

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ABSTRACT

The low heat rejection application in diesel engines has possessions on the fuel consumption, power, combustion efficiency, pollution contents and the fatigue lifetime of engine components. Based on the tests, it was firm that specific fuel consumption was enlarged with biodiesel practice. Exhaust gas temperature and smoke concentration were lessened with biodiesel practice, but enlarged by low heat rejection use. Oxides of nitrogen emission were augmented at a lesser speed, but reduced at higher speed with biodiesel practice and it was augmented by low heat rejection use. In this article, all effects, advantages and disadvantages of low heat rejection application are investigated along with their performance and emissions with vegetable oil based biodiesel.

Keywords: Vegetable oil; Biodiesel; Performance; Emission; Heat rejection

INTRODUCTION

Compression ignition engines are the utmost reliable power sources. In modern years the uncertainty of petroleum fuel readiness has made an obligatory for alternate fuels. India's affirmation for diesel is about '6'times that of petrol. It is a vital need to cultivate substitute fuels with possessions similar to petroleum centered fuels. Swiftly growing costs and doubts regarding petroleum readiness have drawn the consideration of researchers to work on alternate fuel bases. Further, a vital requirement to lessen dependence on petroleum derived fuels for healthier economy and atmosphere [1-3].

Vegetable oils are straight resultant after plants. Plant oils might be edible or non-edible and the plant oil focused economy is increasing fast everywhere the rural part of the nation. Mineral diesel has dissimilar chemical arrangements related with plant oils [4]. Vegetable oils comprise significant quantities of O_2. Its ignition class features are: deprived cold startup, ignition delay and misfire that comprise inadequate burning. Carbon deposits nearby the nozzle hole, on piston rings and on top piston ring grooves are the foremost difficulties through the usage of plant oil as fuel [5]. Owing to the oil crunch in the 1970s and 1980s, petroleum yields became very inadequate and overpriced. At the identical period, increasing global worry owing to ecological pollution from IC engines has produced much consideration on the oxygenated diesel. In the past '3' decades, these problems have caused several research studies to swap diesel fuel by the plant oils or their sources.

Even though it was effective when CI engines were run by the plant oils for small term practice, the higher viscosity and density of plant oils lead to hitches in the injection arrangement and burning chamber of the CI engines for a longer practice. The higher viscosity of plant oils has been resolved in numerous ways, such as heating or blending it with diesel fuels [6-7]. Caterpillar utilized pre-combustion cavity engines with a mixture of 10% plant oil with diesel and kept the similar power production without engine alterations [8]. Tests conducted with crude soybean oil and observed that nozzle deposit creation after 10 hrs process declines engine performance and rises pollutants [9]. Numerous trials conducted with diesel mixtures and Jatropha oil in a CI engine and the evaluated result was stated that the performance and emission features were comparable to that of diesel at low absorption of Jatropha oil in mixtures [10-12].

EXPERIMENTAL SECTION

Vegetable oil

The prospect of plant oils as fuel has been acknowledged since the establishment of CI engines. Plant oil has a higher viscosity for usage in present CI engines as a standby fuel. There are several methods to lessen the viscosity of the plant oil. Micro-Emulsification, Dilution, Transesterification and Pyrolysis are the practices applied to resolve the difficulties met with the high viscosity. One of the collective approaches used to lessen oil viscosity in the biodiesel business is named transesterification. Chemical change of the oil to its matching fatty ester names transesterification [13].

The biodiesel response needs a substance such as NaOH/KOH to divide the oil molecules and methanol/ethanol to syndicate with the detached esters. The chief byproduct is glycerin. The practice lessens the viscosity of the product. Transesterification is broadly used to lessen plant oil viscosity [14-16]. Biodiesel is a renewable fuel and it can be created from oil plants or animal fats. One widespread method for making biodiesel from the oil/fats is transesterification of triglyceride through methanol to form methyl esters.

Biodiesel production process

The schematic of the biodiesel production method as shown in Figure 1 is as follows:

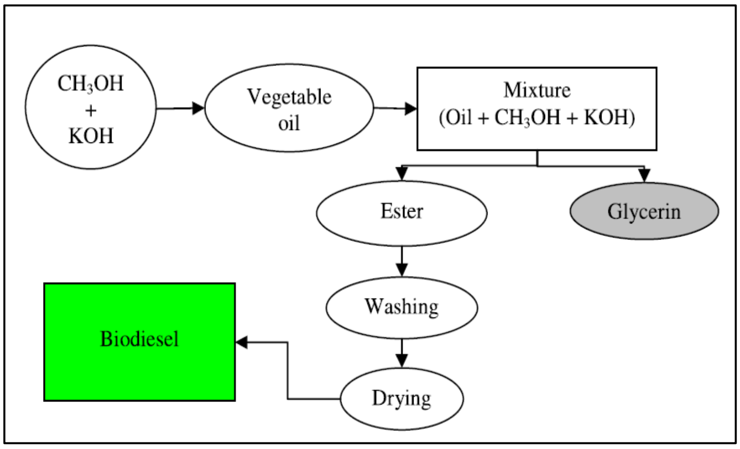


Figure 1: Biodiesel making process

Low Heat Rejection Engines (LHR)

Many investigators have considered biodiesel as an alternate energy basis for CI engines. Though fuel features of biodiesel are ended comparable to the diesel by the aid of numerous means alike transesterification technique, their viscosity is quiet complex than diesel. Growing temperature in the burning cavity in CI engines disturbs competence and pollutant of biodiesel. Since burning cavity temperature is higher in the LHR engines, in which certain or all elements of the burning cavity are layered with a ceramic substance, biodiesel could be utilized more efficiently in CI engines. Since the temperature in the burning cavity is greater in the ceramic layered engines than uncoated engines, it is likely to practice low value fuels in a broader distillation variety [17].

To make apt circumstances for the thermodynamic cycle in the IC engine, it is vital to build the components of the burning cavity from constituents of less thermal conductivity. One of the conceivable approaches to adiabatize an engine is to shelter the exterior of the burning cavity with Ceramic layers. The thermal lining, thus attained is supposed to clue, to a development in the efficiency and a decrease in consumption. Upper temperatures in the burning cavity can also have an optimistic result on CI engines. Very minor part of entire energy provided to the engine is changed into valuable energy in the IC engines. In order to protect energy, it is an improvement to shield the hot components by a thermal shielding coat.

This will diminish the heat transferal over the engine wall and a larger portion of the energy formed could be used, concerning an enlarged efficacy. The variations in the burning practice owing to insulation also disturb exhaust pollutants [18]. Coating engines by ceramic constituents partially or completely has been underway to be utilized newly. The purpose of the lessons of this substance is common to raise the engine performance, to create the components more wear resistant. Ceramic coatings are commonly realistic on the cylinder head, valves and piston by plasma spray technique (22,23).

Plasma Coating Process

Plasma spray practice is one of the advanced expertise for coating method. Ceramic centered composites utilized in this plasma shower practice, are made by a modern wear resistance and thermal wall outcome of the material outward by way of of their chemical and physical possessions [19,20].

Figure 2: The Ceramic-Coated parts of the test engine

The cylinder head, valves, and pistons of the trial engine were covered by a special plasma coating technique. Before coating, a 0.5-mm thickness of material was detached from exteriors by machining to retain the CR of the LHR engine. The burning chamber parts were covered by a Y_2O_3-ZrO_2 layer of 0.35 mm thick over a NiCrAl bond skin about 0.15 mm thick. The Y_2O_3-ZrO_2 was preferred as the ceramic substance because of its stability in a higher temperature. This technique was together inexpensive and easy to achieve. The layered engine components can be perceived in Figure 2.

RESULTS AND DISCUSSION

Hazar *et al.* (21) conducted tests on the single cylinder, 400 Lombardini diesel engines with and without modifications, and observed that the SFC tendencies to rise at less speeds for both the engines (Figure.3). The SFC reduction happened at nearby middle speed for uncoated and coated engine. This is mainly owing to the adequate time, higher burning efficiency and appropriate blend development in the burning cavity at middle engine speeds. He also perceived that CO discharge is higher at lesser speeds in both engines (Figure.4). Burning became inferior in both the engines because of the less temperatures in the burning cavity and subsequently, CO discharge enlarged due to the imperfect burning in both engines at less speeds. Since the local aspects such as pressure, temperature, mix ratio, and O_2 content in the burning cavity disturb ignition and its sustainability in the IC engines, it is perceived evidently that, ceramic covering enhanced these local aspects.

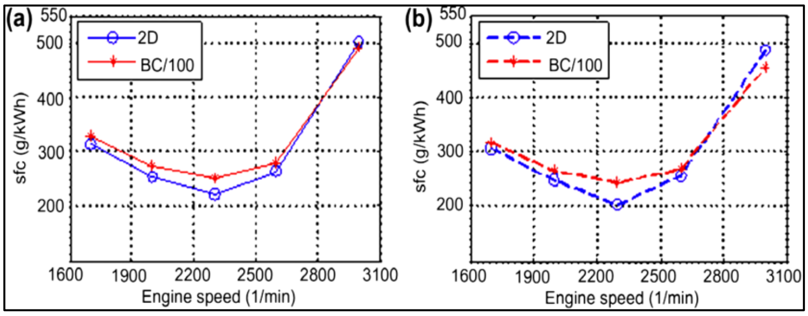


Figure 3: SFC at different speeds in UE (a) and CE (b) engines

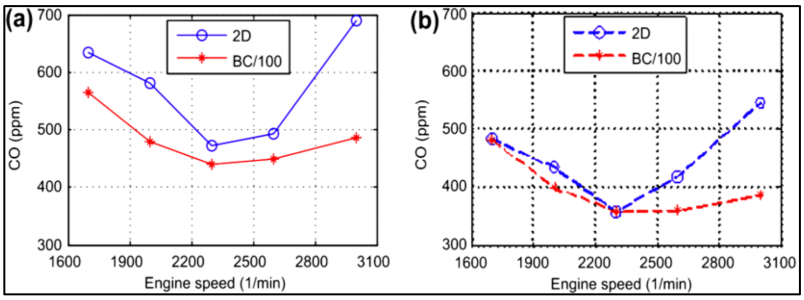


Figure 4: CO at different speeds in UE (a) and CE (b) engines

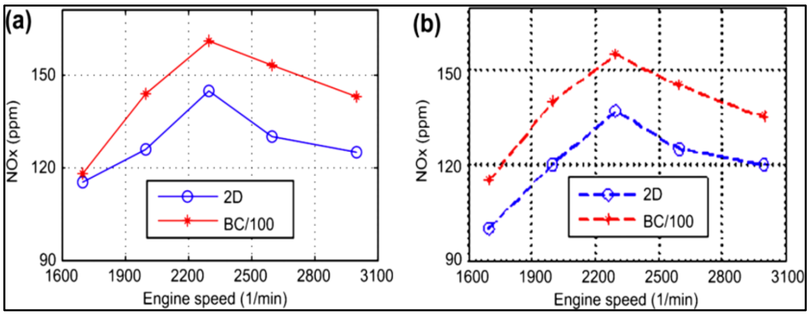


Figure 5: NO_X at different speeds in UE (a) and CE (b) engines

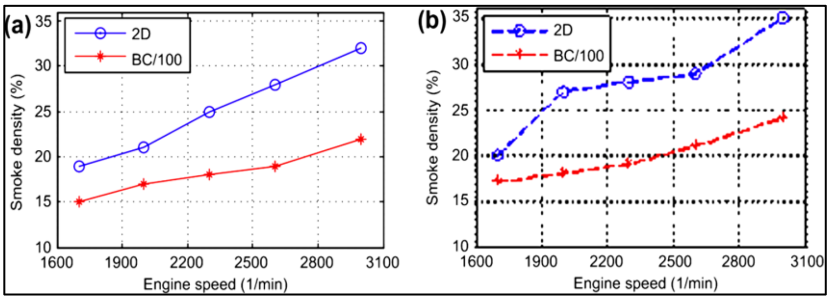


Figure 6: Smoke density at different speeds in UE (a) and CE (b) engines.

He compared the NOx discharge between CE and UE engine, it was firm that, a rise of 4.5% for all the speeds was occurring (Figure.5). The upper burning temperature of the layered engine would be estimated to rise NOx discharges. The rise in burning temperature, conversely, clues to enlarged NOx discharges from the layered engine. He observed that the smoke thickness amplified with the rise in speed for both engines (Figure.6). This is mainly owing to the inadequate time, lesser burning efficiency and rich blend development in the cylinder at upper engine speeds. Since fuel injection rises on each cycle, the requisite air cannot be delivered. This initiated an escalation in smoke development at higher speeds.

Hasimoglu *et al.* (24) experimented with 4cylinder Mercedes-Benz and observed that the BSFC declines with the rise of engine load. The lowest BSFC was attained for LHR Diesel at 1400 rpm (Figure.7). At 2800 rpm, the lowest BSFC was attained for STD Diesel during all engine loads (Figure.8). For STD Biodiesel, the BSFC was increased from 22.6 to 68.4% during all engine loads. For LHR Biodiesel, the BSFC was increased from 36.4 to 84.2% during all engine loads. NOx emission was increased with the increment of engine load during tests. NOx emission of the test engine became the maximum for LHR diesel and the minimum for LHR Biodiesel during all engine loads at 1400 rpm (Figure.9). NOx emission of the test engine became the maximum for LHR diesel and the minimum for LHR Biodiesel during all engine loads at 2800 rpm (Figure.10). This oxygen increases local oxygen concentration in-cylinder so fuel and oxygen molecules can react easily. Thus, local heat release rate and temperature increases. The higher viscosity, deprived volatility and cold stream features of plant oils can source some hitches such as injector coking, filter gumming, engine deposits, piston ring sticky and solidifying of lubrication oil for long-standing usage in CI engines.

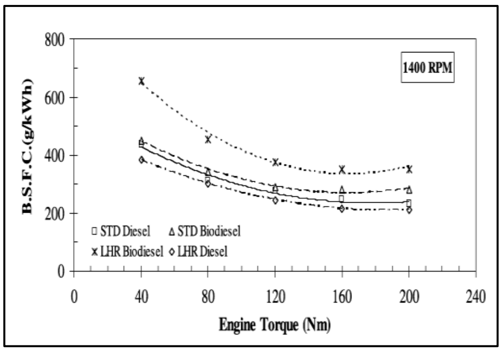


Figure 7: BSFC Vs engine torque at 1400 rpm

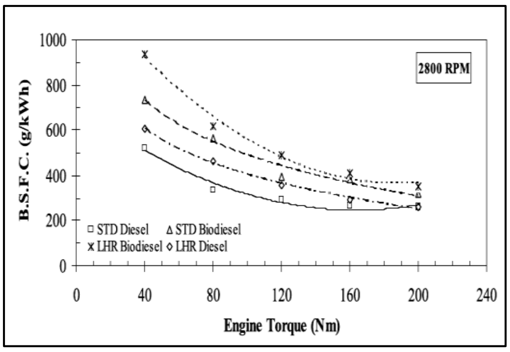
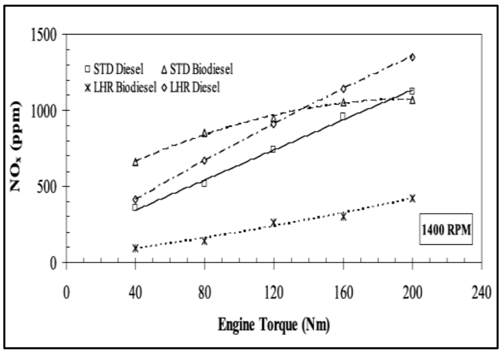


Figure 8: BSFC Vs engine torque at 2800 rpm



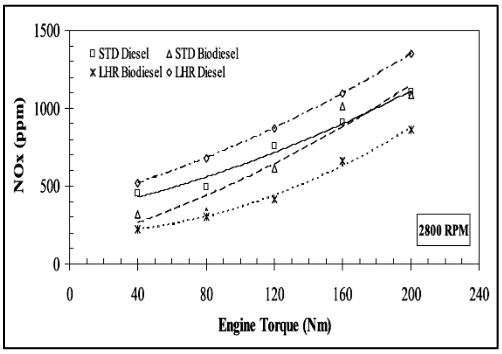


Figure 9: NO_X emissions Vs engine torque at 1400 rpm **Figure 10: NO_X emissions Vs engine torque at 2800 rpm**

Buyukkaya *et al.* (25) et al observed almost 65^0C rise in the burning gas temperature for the LHR engine equated to the normal engine functioning in the identical conditions. The BSFC of the LHR engine were established to be lesser of around 6% than the normal engine. The pollutant features of the shielded engine at sensible and maximum loads seemed to be eye-catching. Particulate discharges diminished remarkably in the LHR engine. These declines were up to 40%. The NOx discharge stages were established to be greater by around 9% equated to the normal engine because of the upper exhaust temperatures in the LHR engine. NOx discharges were perceived to be inferior by 11% for 18^0BTDC in contrast to the normal engine.

Buyukkaya *et al.* (26) noticed that the BSFC of the LHR engine were established to be around 6% lesser than the normal engine at particularly middle speed and definite pressure. For 18^0 BTDC, a relative lessening of 1–2% in the BSFC was documented. Conversely, 16^0 BTDC displayed almost the identical BSCF with the normal engine at 2400 rpm and dissimilar BMEPs. NO_X discharges were lessened in the array of 35–53% when the unusual injection timing was delayed by 4^0 BTDC for LHR engine. But, particulate discharges and BSFC are declined.

Murali Krishna *et al.* (27) noticed that the engine with low grade LHR burning cavity with linseed biodiesel enhanced performance over CE on the aspect of peak BTE, BSFC and coolant load. However, it increased exhaust gas temperatures marginally and reduced volumetric efficiency in comparison with CE.
Kumar *et al.* (28) noticed that the BTE with LHR burning cavity with biodiesel operation was higher, BSEC was lower and EGT was higher in comparison with conventional engine. When equated with CE, with biodiesel operation, at suggested and optimized injection timings, at maximum load, engine with LHR burning cavity diminished smoke levels by 22%, enlarged NOx levels by 9%.

Aydin *et al.* (29) investigated the biodiesel practice in a ceramic coated with MgO, ZrO2 and Al2O3 layer in the diesel engine. Engine performance was significantly enlarged with diminished SFC. HC, CO and smoke were lessened while NOx enlarged in the covered engine.

Balamurugan *et al.* (30) noticed that the SFC decreases, the BTE increases, CO/ HC decreases and NOx increases for Jatropha Biodiesel equated to Diesel with the variation of Torque in LHR engine.

Murthy *et al.* (31) noticed that the LHR engine burning cavity is efficient for alternative fuel like biodiesel rather than neat diesel. The performance, pollutants and burning features were enhanced with progressive injection timing, rise of injector opening pressure and with preheating with both kinds of the burning cavity with biodiesel.

Anantha Raman *et al.* (32) observed the BTE of the low heat rejection engine, marginally increased and the specific energy consumption decreased compared with uncoated engine. The carbon monoxide, unburned hydrocarbon and smoke emissions of the LHR engine is lower than the conventional engine. The exhaust gas temperature and oxides of nitrogen increased with thermal barrier coating due to higher combustion temperature.

Balaji *et al.* (33) tested in a water cooled, single cylinder diesel engine and noticed the lessening in BSFC, Increase in the brake thermal efficiency and the emissions are reduced with LHR coated the engine.

Krishna *et al.* (34) investigated the engine performance with LHR burning chamber comprising of ceramic layered cylinder head fueled with jatropha oil with various injection pressure and timing. Engine with LHR burning cavity with the full introduction of alcohol with jatropha oil displayed enhanced performance. However, it amplified NOx level.

CONCLUSION

Biodiesel exhibited comparable performance features to diesel fuel. Some developments could be attained by changing in-cylinder circumstances of the engines. With the rise of in-cylinder temperatures due to thermal separation, biodiesel displayed enhanced performance features than diesel. The developments in engine competence can be markedly seen, chiefly in less-speed, higher load areas where diesel engines function. Outcomes and reasons attained from this study are précised as follows:

In the LHR engine, the reduction of the ignition delay period affected negatively to BSFC. Owing to the reduced heat rate of biodiesel in comparison to diesel, BSFC was enlarged when the biodiesel was utilized as fuel. Some developments were attained with LHR claims in BSFC values.

Oxygen content of biodiesel was the reason for increased NO_X emission in the exhaust when biodiesel was used. This increased local O_2 concentrations in-cylinder; consequently, NO_X emission was increased in the STD engine at lower speed. While elevated temperatures in the LHR engine caused a rise in NO_X discharge for diesel, a shortened ignition delay period caused a decrease in NO_X emission for biodiesel.

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