International Journal of Management, IT & Engineering
Vol. 8 Issue 12, December 2018,
ISSN: 2249-0558 Impact Factor: 7.119
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

THE ROLE OF BIO-DIESEL AS AN ALTERNATIVE FUEL

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Abstract

In the present scenario, the depletion of world petroleum reserves results in two crisis that are raising prices of fuel and global warming. These fossil fuel reserves may exhaust by 2050. The combustion products of these fossil fuels are causing peak environmental pollution. Hence efforts are being made to find the alternatives. Among all the alternative energy sources, the potential for biofuel energy is numerous. The government is paying considerable attention for the utilization of renewable energy, especially biofuels. Biodiesel is made from vegetable oil, animal fats and non edible seeds. To understand the current scenario about biodiesel utility and its related issues an extensive literature survey has been carried out. The present review highlights the various issues related to biodiesel such as performance emission, and combustion characteristics of a compression ignition diesel engine when it is used as a substitute fuel for unmodified compression ignition engines.

Keywords:
Global Warmimg;
Fossil fuel;
Alternatve energy;
Bio-Diesel;
Non-edible seeds.
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1. Introduction

In fact, the importance of biofuels was realized by man from the time he discovered fire which was generated from wood. The heat generated from wood was used for cooking and heating even in the ancient times. In truth, the famous German inventor Nikolaus August Otto, after whom the engine cycle was named as Otto cycle, was one of the first to make use of ethanol, a source of biofuel. Also, the inventor of diesel engine, Rudolph Diesel designed the engine using peanut oil as the biofuel source to run the engine. During the period 1903 – 1926, the Car designed by Henry Ford used hemp as the running fuel which was a biofuel. But due to the easy availability and cheap prices of crude oil, biofuel has lost its significance slowly. When the fuel crisis hit the world from 1973 - 1979 due to the geopolitical conflicts, once again biofuel rose to fame. OPEC (Organization of the Petroleum Exporting Countries) made a huge cut in their exports to the non OPEC countries. Such a time made the government of various nations think very seriously about biofuels to meet their energy demands. Apart from that, the emission effects, and heavy hike in the price of petroleum products have also made people to think about using biofuels.

Bio-fuel is the fuel which has a bio organic origin. It is combustible in nature and has plant or animal origin. Bio-fuel can be used for the generation of thermal energy by combustion. Biofuels are liquid or gaseous fuels produced from biomass resources and used in place of or in addition to diesel, petrol or other fossil fuels for transport, stationary, portable and other applications. Bio-fuel has gained importance because of its environment friendly properties. It is much more ecologically sustainable than any other fossil fuel that are more commonly used.

If degraded and unproductive agricultural farm lands converted in to biofuel sources of high diversity then a lot of economical and environmental benefits can be realized. Wildlife area can be restored, soil erosion can be prevented, the pollutants that are water borne can be significantly reduced, and carbon dioxide from the atmosphere can be collected as beneficial carbon rich compounds for that soil. In this way the fertility of that land can be restored thus making it useful again. The fast production of biofuel is encouraging lot of research works of generating renewable and clean sources of energy. It was estimated that in the European Union biofuel powered vehicles would constitute 5.75% of the total number of vehicles. And the forecast for

2020 goes in this way that the number of exclusively biofuel powered vehicles would increase up to 10%. The Energy Independence and Security Act of U.S.A. in 2007 mandated that 136 billion litres of biodiesel would be used annually by 2020. This figure shows 6 folds increase compared to the figure of 2006 levels of production. New technologies are being built in order to capture the carbon dioxide from the atmosphere to produce biofuel supplying crops. In this way a significant amount of carbon dioxide can be removed from the atmosphere. This carbon dioxide can be stored as solid carbonates under the earth, inside geological formations or long term repositories.

Biofuels are categorized in to three different parts they are,

1) First generation biofuels: Bio alcohols, Biodiesel, Vegetable oil, Bio ethers, and Biogas.

a) Bio-ethanol: it is obtained from sugar cane. It is primarily produced by the fermentation of molasses.

b) Bio-diesel: it is obtained from vegetable oils like Rapeseed oil, Jatropha, soy or Palm oil Pongamia etc.,.

2) Second generation biofuels: Advanced biofuels like Bio-hydrogen, Bio-methanol and waste fish oil obtained by reaction of the oil with methanol.

3) Third generation biofuels: Micro-Organisms like Algae, and Non-edible seeds.

2. Literaure Review

As the part of literature survey under the area of Bio – Diesel as alternate fuel in compression ignition engines blended with conventional diesel fuel, many research articles, conference papers, books and some research papers are referred and the outcome of those research are discussed in detail as given below

S.Vedharaj et al (2014) derived biodiesel from low cost feedstock; they have extracted Cashew nut shell liquid from cashew nut shells and two stage transesterification was adopted to produce CNSLME (Cashew nut shell liquid methyl ester). Then they have tested the performance of diesel engine powered by CNSLME (25%) blended with conventional diesel (75%) with and without coating by PSZ (Partially stabilized zirconia). From the experimental investigation it was found that, the BTE (Brake thermal efficiency) was increased by 6%, and emissions such as CO

(Carbon monoxide), HC (Hydro carbon) and Smoke were reduced by 27.7%, 7.2% and 14.3% respectively when compared to uncoated engine. Finally simulation study was made using FEA (Finite Element Analysis) shown that the average temperature, heat flux and thermal stress were lower for coated piston [1].

Dan Zeng et al (2014) reviewed that the biodiesel production from low grade feed stocks such as non-edible oils; waste cooking oils etc., using supercritical methanol transesterification process reduces the cost of biodiesel production [2].

Adeeb Hayyan et al (2014) produced Mixed Industrial palm oil (MIPO) by mixing of acidic crude palm oil (ACPO) and sludge palm oil (SPO) in the presence of 1- propanesulphonic acid (1-PSA) as catalyst for the pretreatment of MIPO and concluded that MIPO was a viable raw material for biodiesel production [3].

Hwai Chyuan Ong et al (2014) carried out an experiment to produce biodiesel from Crude Cerbera Manghas biofuel by two-step acid-alkaline transesterification using H_2SO_4 as acid catalyst and KOH as alkaline catalyst and concluded that the neatly explored non-edible oil from CCMO can be considered as a future biodiesel feed sock [4].

K.Srithar et al (2014) carried out an experimental study on single cylinder four stroke direct injection diesel engine using dual fuel (Pongamia pinnata oil and Mustard oil) and their blends with diesel. The experimental results indicated that, Blend A (Diesel 90%, PPEE 5% and MEE 5%), Blend B (Diesel 80%, PPEE 10% and MEE 10%) and Blend C (Diesel 60%, PPEE 20% and MEE 20%) produced slightly lower Co and CO_2 than diesel , so they would be used as an alternative fuel for diesel in the diesel engine [5].

L.Tarabet et al (2014) conducted an experimental investigation on modified DI diesel engine operated with Eucalyptus biodiesel and natural gas under dual fuel mode and results in lower NO_x emissions than the conventional diesel fuel mode [6].

M.Mofijur et al (2014) made a comparative evaluation by experimentation on performance and emission characteristics of Moringa Oleifera oil and Palm oil based biodiesel in a multi cylinder diesel engine. At conclusion it was stated that the MB5 and MB10 biodiesel blends are comparable with those of the PB5 and PB10 biodiesel blends and diesel fuel as the MB5 and MB10 blends reduced the exhaust emissions of diesel fuel [7].

S.Imtenan et al (2014) evaluated the comparative improvement analysis of biodiesel – diesel blends with additives. In this experimental study, Palm Biodiesel – Diesel with the help of additives (15 % Palm-biodiesel, 80 % Diesel and 5 % ethanol, n- butanol or diethyl ether as additive) were taken as fuel in diesel engine. This experiment was ended with increment in Brake power, BTE, and decrement in BSFC, NO and CO emission than 20 % Palm – Biodiesel [8].

Atul Dhar et al (2014) carried out experimental investigation on Performance, emissions and combustion characteristics of Karanja biodiesel in a four cylinder, four stroke direct injection compression ignition (DICI) transportation engine and this experiment showed that, 10 % and 20 % KOME (Karanja oil methyl ester) blends produced maximum torque and lower BSFC, BSCO,BSHC and smoke emissions than pure mineral diesel. But $BSNO_x$ emissions were slightly higher. While the higher biodiesel blends produced slightly lower torque and higher BSFC [9].

Gaurav Paul et al (2014) compared the performance, combustion and emission characteristics of a diesel engine fuelled with Jatropha Biodiesel and conventional fossil diesel. The results showed that the use of jatropha biodiesel decreases its torque and brake thermal efficiency. The decrease being more with increase in the biodiesel share in the blends. BSFC increases with the percentage increase of biodiesel in the blended fuels. Cylinder peak pressure increases and ignition delay period decreases with the increase in biodiesel share in the blended fuels. Use of jatropha biodiesel increases the NO_x emission compared to pure diesel due to the high oxygen content [10].

Mohamed F.Al_Dawody and S.K.Bhatti (2014) analyzed the combustion, performance, and emission parameters of a diesel engine fueled with Soybean biodiesel – Diesel blends. The results indicate that all blends of SME were found to emit significantly lower UHC concentration compared to that of diesel fuel. NO_x emissions are observed to be higher for all blends of SME. At the end they have concluded that the best blending ratio is 20 % SME which gives the same performance compared to diesel fuel and less increase in the NO_x emissions as compared with other SME blends [11].

A.E.Atabani et al (2014) investigated the potential of Calophyllum inophyllum as a feedstock for biodiesel production and concluded that Calophyllum inophyllum seems to be a satisfactory feedstock for future biodiesel production. As far as engine performance and emission characteristics were concerned the authors reported that, the performance of Calophyllum inophyllum methyl ester (CIME) fueled engine was marginally better than the diesel fuelled engine in terms of thermal efficiency, brake specific fuel consumption, smoke opacity, and exhaust emissions including NO_x for entire range of operations [12].

Sanjid Ahmed et al (2014) used Brassica Juncea methyl ester (Mustard Oil) and its blends in compression ignition engine and investigated the performance, emission and noise characteristics. The experimental investigation found that 10 % and 20 % MB (Mustard Biodiesel) blends produced 8 - 13% higher specific fuel consumption, 7 – 8% less brake power, 9 – 12% higher NO, 24 – 42% lower HC, 19 – 40% lower CO and 2 –7% lower noise compared to diesel fuel [13].

Gajendra Singh et al (2014) carried out experimental investigation on HCCI (Homogeneous Charge Compression Ignition) engine fuelled with biodiesel using external mixture formation technique. This experimentation revealed that the chemical kinetics of diesel HCCI was found to be faster compared to biodiesel HCCI. A significant reduction in NO emission was seen with biodiesel blends in HCCI mode. Effect of EGR (Exhaust Gas Recirculation) was investigated and it was found to be a very effective tool to control HCCI combustion [14].

S.Saravanan et al (2014) investigated the effect of injection timing and fuel injection pressure in reducing the NO_x emission of diesel engine fuelled with WCME (waste cooking oil methyl ester) blended with mineral diesel. The experimental results are drawn such as, retardation of injection timing by 2.5 CAD (crank angle degree) decreases the NO_x emission of the engine without significant increase in smoke density. By increasing the fuel injection pressure to 250 bar at the retarded injection timing the percentage increase in smoke density was decreased [15].

A.Sanjid et al (2014) prepared palm and jatropha based biodiesel and made an analysis of performance, exhaust emission and noise on palm – jatropha combined blends in an unmodified diesel engine. The experimental investigation was carried out in a single cylinder diesel engine at different engine speeds ranging from 1400 to 2200 rpm and it was reported that PBJB5 and PBJB10 biodiesels showed a slightly higher BSFC than diesel fuel, all the measured emission parameters and noise emission were significantly reduced except for NO emission. CO emissions for PBJB5 and PBJB10 were 3.69 % and 20.49 % lower than for diesel fuel. The sound levels produced by PBJB5 and PBJB10 were also reduced by 2.5% and 5% compared with diesel fuel due to their lubricity and damping characteristics[16].

D.H.Qi et al (2014) tested a twin cylinder agricultural diesel engine fuelled with 20% Rapeseed oil – 80% Diesel fuel (RSO20) and 50% Rapeseed oil – 50% Diesel fuel (RPO50), and it was concluded that the BSFC of rapeseed oil – diesel blends was higher than that of diesel fuel under all range of engine loads, but the BSEC was improved at high engine loads. The peak cylinder pressure and heat release rate were higher at low engine loads, but almost identical at high engine loads. No_x emission was observed slightly lower at low engine loads and almost identical at high engine loads [17].

R.Satish Kumar et al (2015) derived biodiesel called Manilkara Zapota Methyl Ester (MZME) from Manilkara Zapota Seed using taguchi method, and key properties of MZME are found to meet the requirements of EN 14214 biodiesel standards. Hence it was reported that MZME could be considered as a potential substitute to the fossil diesel [18].

V.K.Shahir et al (2015) through an extensive literature review made a general comment that 20% blending of biodiesel with diesel could be a better choice for long run diesel engine applications without any engine modifications [19].

Md Narun Nabi et al (2015) tested a new renewable Licella biofuel in a four cylinder turbocharged common rail direct injection diesel engine and the blends are designated as R0, R5, R10 and R20, and recorded as with 20% Licella biofuel (R20) into diesel fuel no significant differences found in BP, IP, BMEP, BTE and mechanical efficiency. And it was also noticed that with R20 THC and NO emissions were found to be higher and PM mass emissions were observed to be lower for all Licella blends [20].

Swarup Kumar Nayak et al (2015) examined the influence of compression ratio on combustion characteristics of a VCR engine using Calophyllum inophyllum biodiesel and diesel blends. This test was carried out with a fixed speed of 1500 rpm, full load and at different compression ratios of 16:1, 17:1, and 18:1 with COME blends of C20, C50 and C60. From this investigation the conclusions are drawn as at CR 18, C20 gives better combustion temperature of 1455.32^{0}C and combustion duration of Calophyllum inophyllum biodiesel is more than diesel where as ignition delay is shorter [21].

D.K.Ramesha et al (2015) confirmed the possibility of use of plastic oil and B20 algae biodiesel blend as substitute fuel to diesel engine. The plastic oil is obtained from waste plastic through pyrolysis process and algae oil is derived from microalgae. The experimental investigation revealed that for B20AOME10WPO, BTE increased and the emissions of HC, CO, smoke opacity and particulate matter decreased with a slight increase in NO_x as compared to diesel [22].

G.Vairamuthu et al (2015) carried out an investigation on modified DI diesel engine using Calophyllum inophyllum biodiesel blended with diesel. During this experimentation the effect of nozzle hole geometry (Number of holes and diameter of the hole) on the performance emission and combustion characteristics of a naturally aspirated single cylinder four stroke DI diesel engine using CIME blend was studied. This study results in, the SFC is decreased and the BTE is increased for modified injection system NH5 (No. of nozzle holes = 5) at NOP (Nozzle operating pressure) 250 bar compared to baseline engine having 3 hole fuel injector nozzle operated at NOP 250 bar [23].

K.Venkateswarlu et al (2015) studied the effect of fuel additives and exhaust gas recirculation on combustion and emissions of diesel – biodiesel blends. During this study cetane improver, Di-Tertiary Butyl peroxide (DTBP) is used as a fuel additive to diesel – biodiesel blends to investigate the effect of exhaust gas recirculation. The results reveal that the ignition of biodiesel blends is advanced by a few degrees of crank angle (CA) and consequently peak pressure is preponed by 2 - 3^0 and also the combustion is finished earlier than that of diesel. With increase in percentage of both biodiesel and DTBP, emissions of carbon monoxide reduced by 17 – 19%, hydrocarbon reduced by 23 – 25%. With the combined effect of EGR and DIBP, NO_x emissions were reduced by 33 – 35% when compared to pure diesel without EGR [24].

Isaac JoshuaRamesh Lalvani J et al (2015) investigated the performance and emission characteristics of a diesel engine powered with modified piston. This experiment is carried out in a conventional diesel engine using fossil diesel and 20% blend of adelfa biodiesel [A20] without and with modified piston to increase the turbulence foe better mixing of air and fuel. The engine with modified piston has shown improved brake thermal efficiency, reduced hydrocarbon, carbon monoxide and smoke emissions, but the nitrogen oxide emissions have been found to be slightly higher than the unmodified engine [25].

N.Balakrishnan et al (2015) conducted an experiment on four stroke single cylinder variable compression ratio diesel engine using waste vegetable oil methyl ester and producer gas. The experiment is carried out on the engine with single fuel mode (23% fossil diesel and 77% biodiesel), dual fuel mode (fossil diesel + producer gas) and mixed fuel mode (biodiesel + producer gas). The producer gas is supplied along with air through the air surge tank. During the experimentation it was found that much brake thermal efficiency was achieved with single fuel mode than mixed fuel mode and smoke opacity of mixed fuel mode is much lower than the single fuel mode operation [26].

S.M.Ameer Uddin et al (2015) performed an experimental investigation on diesel engine run with Mustard – Kerosene blends. They have tested the engine performance using Mustard oil blended with Kerosene at different proportions like M20, M30, M40, M50 and M100 (Pure mustard) at different load conditions in four stroke single cylinder diesel engine mounted on a hydraulic dynamometer. They have reported the final experimental results such as, among all the blends M20 and M30 has the minimum BSFC 257.94 gm/KW – hr at 12.5 Kg load and 269.67 gm/kW – hr at12.5 Kg load respectively. Hence they have concluded that M20 can be considered as suitable blend [27].

Ahmet Uyumaz (2015) conducted an experimental study on four stroke HCCI engine in order to determine the effects of pure n-heptane. For this purpose he had taken the blends of n – heptane and n – butanol fuels B20, B30, B40 (including 20%, 30%, 40% n-butanol and 80%., 70%, 60% n – heptane by volume), and the blends of n – heptane and isopropanol fuels P20, P30, P40 (including 20%, 30%, 40% isopropanol and 80%., 70%, 60% n – heptane by volume).

As a result it was found that the start of combustion was advanced with the increasing of inlet air temperature for all test fuels and the start of combustion delayed with increasing percentage of n – butanol and isopropanol. Knocking combustion was seen with B20 and n – heptane test fuels. Minimum combustion duration was observed using B40. Almost zero NO emissions were measured with the fuels apart from B20 and n – heptane [28].

M.Mofijur et al (2015) reviewed the role of biofuels on IC engines emission reduction. This review found that vehicular emission is largely responsible for Green House Gas emission and health hazards. This review indicated that biofuels have the potential to reduce GHG emission more than 80%. Some developed countries have put their target and mandate to use biofuel, for example, the United States wants to use 25% ethanol within 2020. Brazil targets to implement B20 within 2020 and India targets to use B10 country wide within 2017 [29].

M.Mofijur et al (2015) studied the recent developments in IC engine Performance and emissions fuelled with Biodiesel – Diesel – Ethanol blends. This review discussed the effect of mixed blends of biodiesel alcohol and diesel on engine performance and emission parameters of a diesel engine. In this review they have stated that adding ethanol into biodiesel – diesel blend in diesel engines significantly reduce HC, PM, NO_x and smoke emissions but slightly increase fuel consumption. The study concluded that biodiesel – diesel – ethanol blend can be used as a substitute of petro – diesel fuel to reduce dependency on fossil fuel as well as the exhaust emissions of the engine [30].

N.M.S.Hassan et al (2015) experimentally investigated the engine performance and emissions fuelled with biodiesel produced from Australian Beauty Leaf Tree (BTL) and the development of combustion model using computational fluid dynamics (CFD). The test was done with B5 biodiesel (5% BLT blend) and B10 biodiesel (10% BLT blend) and petroleum diesel in a 4 cylinder diesel engine. the test results showed that B10 biodiesel provides significantly reduced engine emissions up to 18% compared to petroleum diesel [31].

Atul Dhar, and Avinash Kumar Agarwal (2015) have analyzed the effect of Karanja biodiesel (KOME) blends on particulate emissions as the particulate mass emissions and particle numbers are responsible for severe adverse health effects. In this experimental investigation the effect of Karanja biodiesel and its blends were tested on particulate size – number distribution, size – surface area distribution and total particulate number concentration in a direct injection compression ignition engine. the result was observed that peak number concentration of particulates increased with engine speed for all test fuels, and total particulate number concentration was highest for KOME100 and lowest for KOME10, and concluded that up to KOME20 was effective in reducing the particulate number emissions [32].

I.M.Atadashi (2015) has done an extensive literature review. During his review he carefully analyzed the different processes that are being adopted to purify the crude biodiesel. Finally this review given the conclusion that membrane separation process is most suitable than water washing and dry washing techniques as biodiesel purification using membrane technique could offer high quality biodiesel fuel with less wastewater discharges and more environmentally friendly [33].

A.K.Azad et al (2015) reviewed that the Moringa Oleifera seed oil has the potential to produce biodiesel. In this review they have discussed the life cycle for moringa biodiesel production such as Cultivation, harvesting, seed collection, oil extraction, biodiesel conversion and its physicochemical properties as per ASTM standards. And also the engine performance test results are discussed. The study concluded that Moringa Oleifera is one of the promising seed that yields 38 – 40% of colourless and odorless vegetable oil, and as a biodiesel it gives lower engine performance, lower emissions of CO, CO_2, PM, HC and slightly higher NO_x emissions with respect to fossil diesel [34].

Zhi – Hui Zhang, Rajasekhar Balasubramanian (2016) A systematic study was conducted to make a comparative evaluation of the effects of blending n – butanol and n – propanol with biodiesel (Waste cooking oil) at 10% and 20% by volume on engine performance. The engine was operated at a constant speed and at three engine loads. The experimental results showed that compared to biodiesel, butanol – biodiesel blends lead to a maximum of 1.6% increase in BTE and an increase in BSFC by 1.9 – 3.9%. Pentanol – biodiesel blends result in an improvement in

BTE and 2% increase in BSFC and it was concluded that butanol being more effective than pentanol [35].

M.L.J.Martin et al (2016) compared the performance and emission characteristics of a direct injection compression ignition engine fuelled with cotton seed oil blended with fossil diesel with and without varying fuel inlet temperature. During this analysis different blends were prepared such as 20:80 Diesel/CSO (20% Diesel), 40:60 Diesel/CSO (40% Diesel), 60:40 Diesel/CSO (60% Diesel), and 80:20 Diesel/CSO (80% Diesel). Test result showed that the brake thermal efficiency increased from 28% to 30.5% with preheated Diesel/CSO blend compared to neat CSO. The smoke, carbon monoxide and unburned hydrocarbon emissions of the engine is also less with the preheated blends. From the test result it has been established that 40:60 Diesel/CSO (40% Diesel) at inlet fuel temperature 343 K can be substituted for diesel [36].

B.Dhinesh et al (2016) carried out an experimental investigation on single cylinder diesel engine power by Cymbopogan flexuous biofuel mixed with nanoparticles. On volume basis 20% Cymbopogan flexuous biofuel (CFB) and 80% diesel fuel blended with various proportions of Cerium Oxide nanoparticles namely C20 – D80 + 10 ppm, C20 – D80 + 20 ppm were prepared. The experimental study disclosed that the use of nanoparticles resulted in higher thermal efficiency and reduced harmful emissions. 20 ppm cerium oxide nanoparticles could effectuate a higher brake thermal efficiency of 4.76% owing to its oxygen buffer characteristics. Among the various blends C20 – D80 + 20 ppm blend claimed reduced HC, CO, NO_x and smoke emission [37].

R.Satish Kumar and K.Suresh Kumar (2016) have introduced a third generation biodiesel resource called Manilkara Zapota Seed Oil. They have produced crude Manilkara Zapota oil (MZO) from Manilkara Zapota Seed by a mechanical expeller, and found the physicochemical properties of crude MZO and Manilkara Zapota Methyl Ester (MZME) after transesterification. Finally they have confirmed that new biodiesel Manilkara Zapota Methyl Ester meets the EN14214 biodiesel standards and could be a reliable substitute to diesel in diesel engine applications [38].

Yahaya Alhassan and Naveen Kumar (2016) have derived biodiesel from Pongamia Pinnata (Karanja) Seed Oil via single step process using Deep Eutectic Solvent Catalysts. During this production process mixture of choline chloride and Para toluene solfonic acid (PTSA) was used with silica support (So – DES) and without support (Un – DES) as heterogeneous and homogeneous catalysts respectively. The result showed that the optimum reaction conditions for esterification of P.pinnata seed oil with Un – DES are; Catalyst loading 1 (wt% / v), reaction time was 120 min and temperature was 343 K, maximum total acid number (TAN) reduction was 0.57 mg/KOH/g and a corresponding biodiesel conversion of 97.53%, the optimal reaction conditions for esterification with So – DES using methanol as solvent are; Catalyst loading 5 (wt% / v), reaction time was 240 min and temperature was 353 K, maximum total acid number (TAN) reduction was 1.42 mg/KOH/g and a corresponding biodiesel conversion of 89.3%. Finally it could be concluded that, DES synthesized from choline chloride and PTSA either with or without supporting material could effectively produce biodiesel with acceptable fuel quality via single step process [39].

Omar I.Awad et al (2016) have experimentally found the effect of fusel oil which is obtained as by-product from the fermentation of alcohol, mixed with diesel on the performance and emission characteristics in a single cylinder CI engine. The test was performed with F20 (20% fusel oil and 80% diesel fuel) and pure diesel in a single cylinder four stroke CI engine. The test was conducted at two engine loads 50% and 75%. The experimental results revealed that the engine power, and the torque for F20 slightly dropped compared with diesel. Furthermore a reduction in nitrogen oxide (NO_x) emissions was observed at all loads and speeds, and it was found that both CO_2 and CO emissions increased [40].

R.M.Alagu and E.Ganapathy Sundaram (2016) prepared Pyrolytic oil from neem seed and experimentally studied the effect of pyrolitic oil and diesel blends on the performance, combustion and emission characteristics in a CI engine. In this study thermal and catalytic pyrolysis were performed on neem seed and a maximum pyrolytic oil yield of 60% was observed for catalytic pyrolysis using Al_2O_3 and K_2CO_3 catalysts. Higher calorific value and pH values of 23.837 MJ / Kg and 5.96 respectively were recorded in the pyrolytic oil obtained from the catalytic pyrolysis using Al_2O_3 catalyst. NB5 and NB10 blends were tested on CI engine and results were drawn as, BSFC was found higher for both NB5 and NB10, BTE was found lesser for both NB5 and NB10, CO, CO_2, HC and NO_x emissions were observed less for both NB5 and NB10 blends.[41].

Mohit Vasudeva et al (2016) have tested a variable compression ratio diesel engine fuelled with esters of crude rice bran oil and fossil diesel blends. Engine performance and exhaust emission results for blends of 10%, 20%, and 40% crude rice bran biodiesel (CB10, CB20, CB40) along with diesel are examined at compression ratio (CR) 15, 16, 17 and 18. Conclusions from experimental investigation are summarized as follows: Blends CB10 and CB20 show almost similar B.S.F.C and B.T.E compared to diesel at all compression ratios, and with increase in compression ratio, maximum cylinder pressure attained for CB10 and CB20, HC emission decreased by 38.4%, CO emission decreased by 22.27%, Co_2 emission increased by 17.43% and NO_x emission increased by 22.76% [42].

Bhaskor J. Bora et al (2016) carried out an experimental evaluation of rice bran biodiesel – biogas run dual fuel variable compression ratio diesel engine. This test was performed to reveal the effect of CR on the performance, combustion and emission characteristics of a biogas run dual fuel diesel engine using rice bran biodiesel (RBB) pilot fuel. The CR was varied from 17 to 18 at standard IT (injection timing) of 23^0 BTDC. At 100% load condition, the BTEs were found to be 20.27%, 19.97% and 18.39% at CRs of 18, 17.5 and 17 respectively under DFM (dual fuel mode) in comparison to 27.76% in diesel mode. On the part of emission there is a reduction in CO and HC under DFM however, there is an increase in No_x and CO_2. Based on the result it can be concluded that the high CR results in better performance, combustion and emission characteristics for a RBB – Biogas run dual fuel diesel engine [43].

P. Bora et al (2016) produced Mesua ferrea L.seed based hybrid fuel and compared its properties with diesel and biodiesel. This investigation showed the possibility for the preparation of a Mesua ferrea L.ethanol-based hybrid fuel system. In this study butan-2-ol was used as surfactant and different fuel properties affected by varying its amount were studied in detail, the fuel properties of Mesua ferrea L.seed oil were found to be improved by the emulsification with ethanol and butan-2ol as surfactant [44].

Rui Galhano dos Santos et al (2016) presented an overview on Valorizing Potato Peel Waste (PPW). In this review the authors have covered almost all the publications focused on potato peel since last 5 years. Finally this overview justified that it can be faced as a tool to be informed about the work that is being conducted concerning the use of PPW as raw material. And also allows a quick and brief knowledge of the latest developments related to the use of PPW [45].

S.Ananthakumar et al (2016) have experimented on variable compression ratio diesel engine to find out the performance, combustion and emission characteristics of Waste plastic Oil blended with diesel. During this investigation the engine was fuelled with WPO (P2.5, P7.5 and P12.5%), Diesel and its blends with Diethyl Ether (2.5%) as an additive to improve the combustion. The experimental result was confirmed that waste plastic oil can be used as alternate to diesel at higher compression ratios due to its high viscosity and low calorific value [46].

J.Hunter Mack et al (2016) during their experimentation two butanol isomers, n-butanol and isobutanol were investigated as potential biofuels for Homogeneous Charge Compression Ignition (HCCI) engines. The emissions produced by combustion of the two butanol isomers are very similar to those of gasoline and ethanol, with No_x emissions expectedly low due to HCCI operation [47].

K.Khiari et al (2016) examined the performance, combustion and emission characteristics of Pistacia Lentiscus (PL) biodiesel in a direct injection diesel engine. the engine was allowed to run with either PL biodiesel or its blends with diesel fuel for several ratios (PL50%, PL30% and PL5% by volume). The results showed that the thermal efficiency is 3% higher for PL biodiesel than for diesel fuel, and the emission levels of CO, UHC and PM are considerably reduced. On the other hand BSFC and Nox emission increased [48].

Vivek W. Khond et al (2016) reported the results of various researches carried -out on the performance and emission characteristics of compression ignition engine using Nono particles additives in diesel, biodiesel and water emulsified fuels. From their extensive review it was resolved that many researchers reported, the best method to control the emissions and improve the performance is the use of nano particles additives and water emulsified fuels. This review also reports the biodiesel fuel as an alternative to diesel fuel by using various nano particle additives [49].

Mustafa Kaan Baltacioglu et al (2016) compared the performance and emission characteristics of a pilot injection diesel engine with the additions of alternative fuels like pure hydrogen, HHO (Hydroxyl) and biodiesel. In order to achieve this goal Helianthus Annuus (Sunflower) biodiesel was produced and blended with volumetric ratio of 10% with diesel fuel, additionally intake air was enriched with pure hydrogen or HHO via intake manifold. The conclusions were drawn as, engine performance values were increased with the enriching the intake air with HHO than pure hydrogen compared to the standard diesel fuel operating condition. On the other hand, in terms of exhaust gas emissions, pure hydrogen provided better results than HHO [50].

Harveer Singh Pali and Naveen Kumar (2016) have tested a single cylinder diesel engine fuelled with Sal Methyl Ester (SME) obtained from Shorea robusta seed oil. During the test performance, combustion and emissions characteristics were observed. The experimental results were shown that SME – Diesel blend is a potential greener fuel for CI engines [51].

Ashok Kumar Yadav et al (2016) have prepared Oleander seed oil using ultrasonic transesterification process, and they have made performance analysis on a single cylinder diesel engine powered by Oleander seed biodiesel. After analyzing the performance and emission parameters it may be concluded that B20 Oleander biodiesel can be used in an unmodified diesel engine effectively [52].

Praveen A. Harari (2017) had conducted an experiment to analyze the performance and emission characteristics of Water Melon biodiesel in a single cylinder four stroke direct injection diesel engine coupled to eddy current dynamometer. During the test the engine was fuelled with various blends like B0, B20, B40, B60, B80 and B100 and the results were compared with pure diesel. The final conclusion revealed that among all the blends B20 showed the closer performance with the neat diesel [53].

J.Kakati et al (2017) have derived Amari tree Seed oil (ATSO) from Amari (Ammora Wallichii King) tree seeds. Amari is a forest based tree; the oil content in the seed was 42.85%, Linoleic 32.84%, and oleic acids 23.01%. The free fatty acid (FFA) was 16% hence two stage transesterification was done to produce biodiesel from ATSO. The physicochemical properties of ATSO were found and most of them conformed to the ASTM D6751 and EN 14214 standards [54].

S.Karthikeyan and A.Prathima (2017) have investigated the environmental effect of Microalgae Methyl Ester which was used as alternate fuel blended with diesel in a compression ignition engine. The engine performance and emission characteristics were measured for the B20 blend sample doped with TiO_2 and SiO_2 nanoparticles at a dosage of 50 ppm and 100 ppm. The experimental results reveal that the use of microalgae biodiesel blend with nano additives in diesel engine has exhibited good improvement in performance characteristic and reduction in exhaust emissions [55].

H.M.Mahmudul et al (2017) through their review they have summarized the information on biodiesel development, feed stocks around the world, oil extraction techniques and biodiesel production processes. They have also discussed the various advantages of biodiesel over fossil diesel. They have emphasized that most of the researchers reported the use of biodiesel in diesel engines though they reduce the engine power slightly but reduce the harmful emission significantly [56].

Ramon Piloto-Rodriguez et al (2017) critically reviewed the impact of the use of biofuels produced from Microalgae to power diesel engines. Biofuels derived from algae can have the lower impact on the environment and the food supply than biofuels produced from crops. Finally the assessment concludes that the biofuel produced from algae or microalgae is a field hardly explored and until today some reference papers contain contradictory results [57].

Sunmeet Singh Kalsi and K.A.Subramanian (2017) the effects of hydrogen blended compressed natural gas (HCNG) on performance, combustion and emissions characteristics of biodiesel fuelled compression ignition engine under reactivity controlled compression ignition (RCCI) mode were studied. The Pongamia Pinnata biodiesel (B100) as pilot fuel was directly injected in to the engine cylinder during compression stroke where as compressed natural gas (CNG) and 18% HCNG as main fuels were injected during suction stroke using electronic controlled unit. The experimental results indicated that BTE of the engine improved significantly with HCNG energy shares. HC, CO, and smoke emissions at all HCNG shares are less as compared to base CNG, however NO_x emissions increased marginally with HCNG but it is still less than base biodiesel [58].

Erinc Uludamar et al (2017) evaluated the vibration level of a hydroxyl (HHO) gas generator installed and diesel engine using different kinds of biodiesel fuels. The effect of HHO gas addition on engine vibration performance was investigated with a Mitsubishi Canter 4D34-2A diesel engine. HHO gas introduced to the test engine via its intake manifold with 2, 4, and 6 L per minute (LPM) flow rates when the engine was fuelled with Sunflower, Canola and Corn biodiesels. Except CoB20, biodiesel blends improved engine vibration up to 5.98%. HHO addition further improved the vibration; the average decrement was 1.23%, 2.345%, and 3.54% for HHO-2, HHO-4, and HHO-6 addition respectively [59].

Shwetha Tripathi and K.A.Subramanian (2017) have carried out an experimental investigation in an automotive diesel engine in order to analyze the effect of Soya Soap stock (by product generated during refining of vegetable oil) based acid oil biodiesel on engine's performance, combustion and emission characteristics. The final out put revealed that, CO, UHC, and smoke emissions with acid oil biodiesel decreased significantly however oxides of nitrogen emission increased in the range from 12% to 38%, in addition to this power output and thermal efficiency marginally decreased [60].

G.V.Churchill et al (2017) have investigated the effect of Indian Jujube seed oil as biodiesel on the performance and emission characteristics of single cylinder diesel engine. The tests were performed with blends of JB25, JB50, JB75 and JB100. The final result has revealed that the BTE is marginally decreased, the emission analysis gave the best result, and the exhaust gas temperature is lower for JB75. And also it reveals that non-edible oil is a promising source which can sustain bio-diesel growth [61].

Mustafa Ozcanli et al (2017) investigated the performance and emission characteristics of a diesel engine fuelled with hydrogen or HHO enriched Castor oil methyl ester (CME) - Diesel blends. The experiment consisted of four sets of tests. The first test was conducted using diesel fuel, the second with CME20, the third with pure CME20 enriched with hydrogen and the fourth set with CME20 fuel enriched with hydroxyl gas (HHO). Intake air was improved with 10 L/min of H_2 or HHO in front of the intake manifold. It was seen that HHO enriched CME has better results compared to pure H_2 enriched CME. The final conclusion was, the effects of both enriched fuels on the engine performance were minimal compared to that of diesel fuel, and however the improvements on exhaust gas emissions were significant [62].

Kerimcan Celebi et al (2017) evaluated the fuel consumption and vibration characteristics of a variable compression ratio compression ignition engine fuelled with high viscosity biodiesel and hydrogen addition. Biodiesels that are produced from Pongamia Pinnata and Tung oils were used as pure biodiesels as well as blended with low sulphur diesel fuel at the volume ratios of 50% and 75%, furthermore hydrogen gas was injected into intake manifold in order to evaluate its effect with the usage of high viscous liquid fuels. The experiment demonstrated that, brake specific fuel consumption was increased with biodiesel fuels and it is decreased by H_2 addition. Addition of H_2 further improved the vibration for low and medium condition. Higher loads caused significant increment on engine body vibration [63].

M.Rengasamy et al (2017) extracted Oil from Artocarpus heterophyllus (Jackfruit) seeds and studied its application in Biodiesel production. This study includes the optimization of oil from feasible methods with respective solvents and the optimization based on the amount of oil yield. The most efficient yield was obtained in microwave oven extraction process resulting in 19.8% of yield using methanol was solvent. The biodiesel yield obtained was about 92% by transesterification at 65^0C reaction temperature, 1: 9 molar ratio of oil: methanol and 400 rpm of stirring speed for 120 minutes with 1 wt% of sodium hydroxide as catalyst [64].

3. Conclusion

From the above discussions it could be concluded that, the role of alternative source of energy especially in the form of biodiesel derived from micro-organisms and non-edible seeds getting appreciated in the coming days. Because to grow micro-organisms like algae, arable lands are not needed and non-edible seed such as malikarazapota, and artocarpus heterophyllus does not affect the cost of food products. Hence the future research work on bio-diesel depends upon the micro-organisms and non-edible seeds.

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