An Overview on Performance, Combustion and Emission Parameters for Single and Dual Blend Biodiesel used in IC Engine

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Abstract—The I.C. engine plays a major role in our mobility and it will continue to do so in the distant future as well. But it will also have to contribute to the protection of the world’s climate and the conservation of our limited reserves of fossil fuel. Vehicles are the main sources for environmental pollution especially those associated with diesel engines. It causes a number of health diseases and harm to the ecosystem. It is very urgent to find alternative fuel for vehicles. Biofuel is an alternative for vehicles which have potential to reduce engine emissions and maintain the air quality better. Alternative source can be found out which can be produced from nearby and locally available sources such as Alcohol, Biodiesel, Vegetable oil etc. Biodiesel can be produced with Jatropha oil, Karanja oil, Mahua oil, Cottonseed oil, Palm oil, Soybean oil etc. Biodiesel can be used in any proportion in internal combustion engine. This paper reviews the various properties, engine performance, emission characteristics and combustion parameters experimentally carried out by various researchers.

Key words: Single Blend Biodiesel, Dual Blend Biodiesel

I. INTRODUCTION

The continuous increasing demand for energy and the decreasing petroleum resources has led to the search for alternative fuel which is renewable and sustainable. Energy is one of the most important resources [30] for mankind and its sustainable development. Today, the energy crisis becomes one of the global issues confronting us. Fuels are of great importance because they can be burned to produce significant amounts of energy. Many aspects of everyday life rely on fuels, in particular the transport of goods and people. Main energy resources come from fossil fuels such as petrol oil, coal and natural gas. Fossil fuel contributes 80% of the world’s energy needs. Most industries use diesel machines for the production process. In the transportation sector, private vehicles, buses, trucks, and ships also consume significant amounts of diesel and gasoline. This situation leads to a strong dependence of everyday life on fossil fuels. However, the growth of the population is not covered by domestic crude oil production.

Fossil oils are fuels which come from ancient animals and microorganisms. Fossil fuel formation requires millions of years. Thus, fossil oils belong to non-renewable energy sources. An increase of the oil price often leads to economic recessions, as well as global and international conflicts. Especially in some developing countries, the great development in the economy in fossil fuel resources will be consumed in only 65 more years. In addition the emission produced by the combustion of fossil fuels also contributes to the air pollution and global warming. Hence, renewable and clean alternative fuels have received increasing attention for current and future utilization. Biodiesel as one promising alternative to fossil fuel for diesel engines has become increasingly important due to environmental consequences of petroleum-fuelled diesel engines and the decreasing petroleum resources. Biodiesel can be produced by chemically combining any natural oil or fat with an alcohol such as methanol or ethanol. Methanol has been the most commonly used alcohol in the commercial production of biodiesel. Lots of researches on biodiesel have shown that the fuel made by vegetable oil can be used properly on diesel engines. In fact the energy density of biodiesel is quite close to regular diesel. Biodiesel can be produced by transesterification process in the presence of acid catalysts. Similarities between the combustion properties of biodiesel and petroleum-derived diesel have made the former one of the most promising renewable and sustainable fuels for the automobile.

When biodiesel is used as a substitute for diesel, it is highly essential to understand the parameters that affect the combustion phenomenon which will in turn have direct impact on thermal efficiency and emission. In the present energy scenario lot of efforts is being focused on improving the thermal efficiency of IC engines with reduction in emissions. The problem of increasing demand for high brake power and the fast depletion of the fuels [30] demand severe controls on power and a high level of fuel economy. [19].

A. Vegetable Oil as an Engine Fuel

Dr. Rudolf Diesel invented an engine which runs on fuel including coal dust suspended in water, heavy mineral oil, and vegetable oils. Dr. Diesel’s first engine experiments were catastrophic failures, but by the time he showed his engine at the World Exhibition in Paris in 1900, his engine was running on 100% peanut oil. In 1911 he stated “The diesel engine can be fed with vegetable oils and would help considerably in the development of agriculture of the countries, which use it”. In 1912, Diesel said, “The use of vegetable oils for engine fuels may seem insignificant today. But such oils may become in course of time as important as petroleum and the coal tar products of the present time”. In the 1930s and 1940s, vegetable oils were used as diesel substitutes from time to time, but usually only in emergency situations. Recently, because of increase in crude oil prices, limited resources of fossil oil and environmental concerns, there has been a renewed focus on vegetable oils and animal fats to make biodiesel. [2]. Because of rapid decline in crude oil reserves, the use of vegetable oil is increasing. Depending upon climate and soil conditions, different nations are looking into different vegetable oils for diesel fuels. Vegetable oil in its raw form is not directly used in engine; it is converted into biodiesel by the process known as trasesterification.
B. Transesterification

There are four different ways through which non-edible oils can be converted into methyl esters are transesterification [40], blending, emulsion[30] and pyrolysis [30] [31] out of which transesterification is the most commonly used method. [29] Vegetable oil has to undergo the process called trasesterification to be usable in internal combustion engine. Biodiesel is biodegradable, non-toxic and essentially free from sulfur; it is renewable and can be produced from agriculture and plant resources. In trasesterification process the reaction of a fat or oil with an alcohol [41] taking place to form esters and glycerol. [23]. To improve the reaction rate and yield catalyst [41] is used. High viscosity, low volatility and a tendency for polymerization in the cylinder are root causes of many problems associated with direct use of these oils as fuels. The process of transesterification yield vegetable oil ester, which has shown promises as alternative diesel fuel as a result of improved viscosity and volatility. [2].

![Fig. 1: Transesterification reaction [16][22][27](Image 380x31 to 516x43)](image)

In this figure R1, R2, R3 represent long carbon chains. [27] In the transesterification process methanol and ethanol are more common. Methanol is more extensively used due to its low cost and physiochemical advantages with triglycerides and alkali are dissolved in it.[16].

C. Biodiesel Standard

Biodiesel has a number of standards for its quality. The European standard for biodiesel is EN 14214, which is translated into the respective national standards for each country that forms the CEN (European Committee for Standardization) area e.g., for the United Kingdom, BS EN 14214 and for Germany DIN EN 14214. It may be used outside the CEN area as well. The main difference that exists between EN 14214 standards of different countries is the national annex detailing climate related requirements of biodiesel in different CEN member countries.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>ASTM D-6751 / BIS Standards for Biodiesel</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flash point (closed cup)</td>
<td>130°C min. (150°C average)</td>
</tr>
<tr>
<td>2</td>
<td>Water and sediment</td>
<td>0.050% by vol., max.</td>
</tr>
<tr>
<td>3</td>
<td>Kinematic viscosity at 40°C</td>
<td>1.9-6.0 mm2/s</td>
</tr>
<tr>
<td>4</td>
<td>Sulfated ash</td>
<td>0.020% by mass, max.</td>
</tr>
<tr>
<td>5</td>
<td>Sulfur</td>
<td>0.05% by mass, max.</td>
</tr>
<tr>
<td>6</td>
<td>Copper strip corrosion</td>
<td>No. 3 max</td>
</tr>
<tr>
<td>7</td>
<td>Cetane</td>
<td>47 min.</td>
</tr>
<tr>
<td>8</td>
<td>Carbon residue</td>
<td>0.050% by mass, max.</td>
</tr>
<tr>
<td>9</td>
<td>Acid number -- mg KOH/g</td>
<td>0.80 max.</td>
</tr>
<tr>
<td>10</td>
<td>Free glycerin</td>
<td>0.020 % mass</td>
</tr>
</tbody>
</table>

Table 1: ASTM D-6751/BIS Standards for Biodiesel [19]

II. PROPERTIES OF BIODIESEL

The properties of biodiesel are very close and similar to the conventional fuels; therefore biodiesel becomes a very good and low cost alternative to the diesel fuel. Transesterification process reduces the molecular weight to one third of the triglycerides, viscosity by factor about eight and slightly increases the volatility. Many scientists and researchers had developed very different methodologies for the production of biodiesel from different feed stocks of vegetable oil and animal fats. Parag Saxena et.al. [9]. There are various thermodynamic and physical properties of feed oil which are very important for the process. Thermo-physical properties of Biodiesel are used for the characterization of Biodiesel and they are also required for the combustion process. Physical properties of Biodiesel and their values or range are given below in the Table 2.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Biodiesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Formula name</td>
<td>Fatty Acid Methyl Ester (FAME)</td>
</tr>
<tr>
<td>Kinematic viscosity range (mm²/s, at 313 K)</td>
<td>3.3–5.2</td>
</tr>
<tr>
<td>Density Range (kg/m³, at 288 K)</td>
<td>860–894</td>
</tr>
<tr>
<td>Boiling point range (K)</td>
<td>&gt;475</td>
</tr>
<tr>
<td>Flash point range (K)</td>
<td>420–450</td>
</tr>
<tr>
<td>Distillation range (K)</td>
<td>470–600</td>
</tr>
<tr>
<td>Vapor pressure (mm Hg, at 295K)</td>
<td>&lt;5</td>
</tr>
<tr>
<td>Solubility in water</td>
<td>Insoluble in water</td>
</tr>
<tr>
<td>Physical Appearance</td>
<td>Light to dark yellow, clear liquid</td>
</tr>
<tr>
<td>Odor</td>
<td>Light musty/soapy odour</td>
</tr>
<tr>
<td>Biodegradability</td>
<td>More biodegradable than petroleum Diesel</td>
</tr>
<tr>
<td>Reactivity</td>
<td>Stable, but avoid strong oxidizing agents</td>
</tr>
</tbody>
</table>

Table 2: Physical Properties Of Biodiesel [39] [42] Venkata Ramesh Mamilla et.al. [10] Studied the properties of karanja oil biodiesel produced by transesterification in the presence of NaOH catalyst. Karanja is a medium sized tree which found almost throughout India and can grow in humid as well as subtropical environments with annual rainfall ranging between 500 and 2500 mm. A maximum conversion of 92% (oil to ester) was achieved at 600c. He concluded that the viscosity of biodiesel oil is nearer to that of diesel and the calorific value is about 12% less than that of diesel. More lubricating than diesel, so it increases the life of engines. High flash point and hence safe to transport and store, Oxygenated fuel and hence clean burning. Low viscosity and hence improved injection and atomization, Cetane no. of esters is greater, reduced emissions, 90%
reduction in cancer risk, Provides domestic, renewable energy.

Ogunwole O.A.et.al. [11] His work deals with the production of Biodiesel from Jatropha oil also known as Curcas oil. The production consisted of very few materials which was sourced for locally and makes the fuel easily produced without much complication. Jatropha oil was heated to 60°C, a solution of Potassium methoxide also at 600°C was added and stirred continuously for one hour. It was left to settle for 24 hours. Glycerine is then removed from the sample by decantation. The sample is then washed and dried. He conclude that the manufacture and use of biodiesel using the locally available Jatropha oil from the seed is viable for use as biodiesel in the form of B100 as 100% biodiesel or in combination of regular diesel. [53] Materials for use in the manufacture of biodiesel are readily available without the need of highly specialized equipment or scarce chemicals. R.D. Misra [12] evaluated cold flow properties of different biodiesel with various additives such as methanol, ethanol, kerosene, Mg, etc. to improve the viscosity, pour point and cloud point. Addition of additives improves the low temperature properties of biodiesel for their convenient handling and usage at different climate condition. Improvement in combustion parameters and emission parameters of CI engines also discussed with addition of additives. Sayyed Siraj R[39] reviews the characterization of biodiesel; the Physio-Chemical properties like Density, Kinematic Viscosity, Flash Point, Cetane Number, and the heating value these are related to combustion and the availability of various feedstock for biodiesel production in the world. H.K. Rashedul [43] reviewed that loss in engine power due to low temperature properties and lower heating value of biodiesel compared to diesel. The low temperature properties of biodiesel fuels are less favorable than diesel fuel. However, blending with additives like ethanol, methanol and cold flow improver additives improves [44] the cold flow performance. The addition of metal based additives improves the flash point, reduces the pour point and viscosity of biodiesel fuel more as compared to other additives. The addition of oxygenated additives reduces the density and viscosity as well as increases the oxygen content of biodiesel fuel as compared to other additives. The addition of antioxidant increases flash point, cetane number and oxidation stability but reduces calorific value of biodiesel fuels. A. Amin [47] proposed empirical correlations to predict the kinematic viscosity, density, and calorific value for a mixture of castor oil and diesel and developed equations to predict the kinematic viscosity, density, and calorific value for castor oil and diesel blend. Godwin Kafui Ayetor [51] discussed the effect of sulphuric acid (H2SO4) on viscosity, Effect of methanol to oil ratio on yield and Effect of base catalyst concentration on yield. Biodiesel is produced by two-step method.

III. PERFORMANCE PARAMETERS AND EMISSION PARAMETERS FOR BIODIESEL

The performance parameters such as power output, specific fuel consumption, brake thermal efficiency of different biodiesels has been reviewed as follows,

Gaurav Paul et. al. [13] tested double cylinder, constant speed of 1500rpm, direct injection diesel engine which is directly coupled to a hydraulic dynamometer of maximum load capacity 20 kgf. The experiment is conducted at varying load and water pressure is at 1.5 kg/cm². Diesel-RK software is used to compare the experimental data with simulated data. The experiments were carried out using pure diesel (B0) and pure jatropha biodiesel (JB100) as fuels.[49]. Brake specific fuel consumption (BSFC) increases and brake thermal efficiency decreases with the use of jatropha biodiesel. Experimentally, pure diesel has maximum efficiency 29.6%, where as pure biodiesel has maximum efficiency of 21.2%. NOx and CO₂ emission also found to increase and smoke and PM emission decreases for the same. Mayank Chhabra [4] studied engine performance at different compression ratios from 12 to 18. The experiments were conducted using B10, B20 and B40 blends of crude rice bran bio-diesel. From the experimental investigation it was found that 14 is the most optimum CR. K.Dilip Kumar [23] found that C20 that is 20% cotton seed oil methyl ester and 80% diesel is optimum blend which can increase break thermal efficiency and lowers the emissions. Basavaraj M. Shrigiri et. al. [14] cotton seed oil biodiesel and neem kernel oil biodiesel are used as alternative fuels [46][54] in low heat rejection engine (LHR), in which the combustion chamber temperature is increased by thermal barrier coating on piston face. It was found that, at peak load the brake thermal efficiency is lower by 5.91% and 7.07% and BSFC is higher by 28.57% and 10.71% for cotton seed and neem kernel oil methyl esters in LHR engine, respectively when compared with conventional diesel fuel used in normal engine and increase in NOx emission also slight increase in CO, smoke and HC emissions. Combustion characteristics Crank angle and crank pressure also studied. Mohd Hafizil Mat Yasin et.al.[21] produced biodiesel through transesterification processes. Palm-biodiesel has higher oxygen and lower sulfur but no aromatic ring in the molecule, more biodegradable and environmentally-safe. The study was conducted in a Mitsubishi 4D68 SOHC in-line four stroke, direct injection diesel engine equipped with diaphragm type EGR at 4500 rpm. The engine was coupled to a 150 kW ECB eddy current dynamometer equipped with Dynalec controller which used to control the engine speed and torque. According to the experimental results, diesel engine operating with palm biodiesel and EGR reduced the brake power output, decreased the engine torque, increased fuel consumption, decreased NOx and absolute slight increment in other emissions include CO₂, CO and particulate matters. Duple Sinha et. al. [15] investigated production of biodiesel from waste cotton seed oil using low cost catalyst to study engine performance and emission characteristics. Waste egg shell used as catalyst by crushing into small piece and calcined into muffle furnace at 800°C for 3 h to convert into CaO which is refluxed in water at 70°C for 4 h and after that dried in hot air oven at 100°C for 10 h. Test conducted with pure diesel, B5, B10 and B15. The specific fuel consumption of biodiesel fuel blends (B10 and B20) were 0.340 kg/kW h and 0.380 kg/kW h, respectively. The biodiesel blends B10 and B20 resulted considerably showed an improved emission characteristic with lower unburnt HC, CO emission. Ravindra A Patil et.al. [17] Studied performance, emission and combustion parameters using palm straight vegetable oil as a fuel for single cylinder, water cooled engine at varying loads. He found increase in efficiencies with increase in load because of poor volatility of palm oil poor combustion of engine. The
brake specific energy consumption of palm oil biodiesel is more as compare to diesel for all loads. Poor combustion results in increases in CO emission from the engine. NOx emission decreases with increase in blends of palm oil biodiesel. Engine performs best for 10% palm oil blend at 90% load condition. Ashok Kumar Yadav et.al. [20] Biodiesel from Oleander oil (OOME), kusum oil (KOME) and bitter groundnut oil (BGOME) is prepared from transesterification process. The CO, HC emission and smoke opacity found slightly less, slightly more NOx emission and reduction in brake thermal efficiency than that of diesel. Bhaskor J. Bora [25] evaluated effect of compression ratio on performance, combustion and emission characteristics of a rice bran biodiesel-biogas run dual fuel diesel engine. To carry out this investigation, a 3.5 kW single cylinder, DI, NA, water cooled, VCR diesel engine is converted into biogas run dual fuel diesel engine. Experiments have been conducted at different loading conditions (20%, 40%, 60%, 80% and 100%) at the IT of 23° BTDC for three CRs of 18, 17.5 and 17 respectively. Based on the results of this investigation, it can be concluded that the high CR results in better performance, combustion and emission characteristics of a rice bran biodiesel-biogas run dual fuel diesel engine. Santhosh B [26] investigated performance with mahua biodiesel produced with Magnesium Phosphate as Catalyst and used as fuel in CI engine. Pollutant CO, CO2 and HC reduced with use of biodiesel but NOx increases. Purna C. Mishra et.al. [27] used mahua biodiesel with Di-methyl carbonate as additive.[29]. The result shows addition of 10% additives is best suited for CI engine. Biodiesel with 15% additive has better thermal efficiency. Pure bio-diesel has highest equivalence ratio when compared with all the test fuels, C. Syed Aalam [28] to investigate the performance parameter aluminium oxide nanoparticles (ANPs) were added to Mahua biodiesel blend in different proportions; found the enhancement in brake thermal efficiency and marginal reduction in pollutant such as CO, HC and smoke. Addition of nano particles increases the peak pressure and reduces ignition delay also increases heat release rate. R. Senthil Kumar [31] uses karaja biodiesel with tyre pyrolysis oil shows longer ignition delay, as a result of the lower cetane number of blend. He investigated performance, combustion and emission parameters. H. M. Dharmadhikari [34] found that the oil mixture will not ensure the desirable results unless the working parameters are readjusted according to the results of experimentation. The performance is slightly reduced while brake specific fuel consumption is increased when using biodiesels however, further investigations to explore the knowledge of dynamics combustion with biodiesel as fuel is needed for the better optimization. Ajit Mane et. al. [35] found that the waste cooking oil disposal is major problem as it cannot reuse for cooking, which causes undesirable effect on human health. To overcome this cause biodiesel is produced from waste cooking oil which offers significant benefits on economic aspect, environmental aspect and waste management of cooking oil and performance parameter were studied. S. Nagaraja [36] investigated the effect of variable compression ratio brake power, mechanical efficiency, indicated mean effective pressure and emission characteristics. Found maximum mechanical efficiency at higher compression ratio with O20 palm biodiesel blend and higher CO2 emission from low compression ratio to high compression ratio. 

Raghavendra [45] uses turmeric oil as additive which slightly increases the thermal efficiency and reduces the emission like CO, HC, NOx, and CO2 when during the loading conditions at constant speed. Turmeric oil obtained by extracting ginger and dried rootstock of turmeric. Turmeric fuel additive can also be used in other non-edible like as Karanja, Jatropha, Azadiracta indica and Simaruba oils. Mr. M. Krishnamoorthy [48] reviews the combustion, performance and emission characteristics of diesel and biodiesel fuel blend with DEE (Diethyl Ether) additive. Additive improves the engine performance and emission characteristics. Reduction in BSFC and increase in BTE was found by adding DEE addictive. J. Sadhik Basha [50] experimental investigation was conducted in a single cylinder constant speed diesel engine to establish the effects of Carbon Nanotubes (CNT) with the Jatropha Methyl Esters (JME) emulsion fuel. Dwivedi et.al. [55] did a comprehensive review of engine performance and emissions using biodiesel from different feed stocks and to compare that with the diesel. From the review it was found that the use of biodiesel leads to the substantial reduction in PM, HC and CO emissions accompanying with the imperceptible power loss, the increase in fuel consumption and the increase in NOx emission on conventional diesel engine with no or fewer modification. J. Allen Jeffrey et.al. [57] focused on experimental investigation of neem oil biodiesel along with HHO gas to evaluate performance and emission parameter of CI engine. HHO gas produced from electrolysis process and sent along the intake manifold with the intake air. Shraddha R Jogdhankar [59][56][58] produced biodiesel from neem oil by transesterification process. Performance parameter evaluated which showed lower but comparable thermal efficiency with diesel.

A. Dual Blend Biodiesel

To understand the effect of dual biodiesel, significant amount of biodiesels is used in blending. The lower biodiesel blends were selected in par with India’s National Policy on Bio-Fuels. The higher biodiesel blends were prepared to understand the effect of mixing the two kinds of biodiesel. K. Srithar et.al. [1] enlightens the physical–chemical properties according to requirements and test methods, performance and emission analysis of the mixed fuels of pongamia pinnata (also known as karanja) biodiesel, jatropha biodiesel and diesel fuel blends.[32]. Experimental analysis was conducted at 0, 20, 40, 60, 80 and 100% of rated load using six different dual biodiesel mixtures (DPJ 1, DPJ 2, DPJ 3, DPJ 4, DPJ 5 and DPJ 6). From this analysis, the calorific value and kinematic viscosity of DPJ 1 was closer to diesel values. The cetane number of DPJ blends was higher than those of diesel. The flashpoint temperature of DPJ blends was higher than that of diesel fuel, facilitating safe transport and storage. From the performance analysis, the thermal efficiency of blend DPJ 1 and DPJ 2 were very closer to the diesel values. The specific fuel consumption values of dual biodiesel blends were comparable to that of diesel. From the emission analysis, the DPJ blends were produced lower HC and CO than those of diesel. The DPJ blends gave higher NOx than those of diesel. Based on these results, DPJ 1 and DPJ 2 were closer to diesel. K. Srithar et.al. [5] present study which brings out an experiment of two biodiesels from pongamia pinnata oil and mustard oil and they are blended with diesel at various mixing ratios. The two biodiesels (pongamia
pinnata oil and Mustard oil) are prepared by the transesterification process. The dual biodiesel blends were prepared in different proportions as: Blend A-Diesel 90%, PPEE 5% and MEE 5% by volume basis; Blend B Diesel 80%, PPEE 10% and MEE 10% by volume basis; Blend C-Diesel 60%, PPEE 20% and MEE 20% by volume basis; Blend D-Diesel 40%, PPEE 30% and MEE 30% by volume basis; Blend E-Diesel 20%, PPEE 40% and MEE 40% by volume basis and Blend F-Diesel 0%, PPEE 50% and MEE 50% by volume basis. The various properties like kinematic viscosity, specific gravity, calorific value, flash point temperature and fire point temperature of baseline fuel, raw oils and two biodiesel mixed blends were determined by using ASTM methods and compared with diesel properties. He concluded that the thermal efficiency and mechanical efficiency of Blend A were slightly higher than the diesel. Blend B and Blend C were very closer to the diesel values. The specific fuel consumption values of dual biodiesel blends were comparable to diesel. Blend A and Blend B produced slightly lower CO and CO2 than diesel. This is a considerable advantage over diesel while using the dual biodiesel blends. The dual biodiesel blends gave higher smoke opacity, HC and NOx than diesel. But for the Blend A, Blend B and Blend C the smoke opacity was nearer to diesel. Therefore, it may be concluded that dual biodiesel blends of Blend A, Blend B and Blend C would be used as an alternative fuel for diesel in the diesel engines. R.Thirunavukarasu et. al. [6] present study on an experiment of two biodiesels from Pongamia Pinnata oil and Neem Oil.[33]. They are blended with diesel at various mixing ratios. The dual biodiesel Blends were prepared in different proportions as: Blend A PD 90%, PPBD 5% and NBD 5% by volume basis; Blend B PD 80%, PPBD 10% and NBD 10% by volume basis; Blend C PD 60%, PPBD 20% and NBD 20% by volume basis; Blend D PD 40%, PPBD 30% and NBD 30% by volume basis; Blend E PD 20%, PPBD40% and NBD 40% by volume basis and Blend F PD 0%, PPBD 50% and NBD 50% by volume basis. The experiments were conducted on a four stroke single cylinder air cooled diesel engine with electrical dynamo meter loading and the performance characteristics were compared with data of petroleum diesel fuel. Tests were conducted at a constant speed of 2500 rpm and at different loads for all dual biodiesel blends. The smoke opacity of the exhaust gases was measured by the AVL make smoke meter. The exhaust emissions were measured by the five gas Analyzer. He concluded that the thermal efficiency and mechanical efficiency of Blend A were slightly higher than the diesel. Blend B and Blend C were very closer to the diesel values. Biodiesel blends of Blend A, Blend B and Blend C would be used as an alternative fuel for diesel in the diesel engines. Ankur Nalgunwar et.al. [7] Uses a dual biodiesel blend, mixture of two different kinds of biodiesel namely palm (Elaeis guineensis) and jatropha (Jatropha curcas) in diesel. His result shows that the sample D90JB5PB5 showed 4.65% 474 average increase in brake power than those operated with conventional diesel. Brake specific fuel consumption, D90JB5PB5 showed 0.91% average reduction compared to diesel. Samples, D60JB20PB20 and D20JB40PB40 showed 12% and 15.4% average increase respectively in brake thermal efficiency compared to conventional diesel. For CO emission, reductions were estimated at 7.1%, 17.7% and 14.5% for D90JB5PB5, D80JB10PB10 and D70JB15PB15 samples respectively when compared to conventional diesel. Lower blends of biodiesel samples D90JB5PB5 and D80JB10PB10 showed an average 5.3% and 9.2% increase in NOx emissions than diesel respectively. Prem Kumar et. al.[8] the aim of the present work is to evaluate the fuel properties and investigate the impact on engine performance using Pongamia and waste cooking biodiesel and their ternary blend with diesel. Experimental set up consist of 4-stroke, single acting high speed compression ignition diesel engine having 15.6:1 compression ratio. The dual biodiesel Blends were prepared in different proportions as: PB100 (pure pongamia biodiesel), WCB100 (pure waste cooking oil biodiesel), WCB10:PB10:D80 (80% Diesel 10% waste cooking &10% pongamia biodiesel), WCB20:PB20:D60 (60% Diesel 20% waste cooking & 20% pongamia biodiesel) and WCB30:PB30:D40 (40% Diesel 30% waste cooking & 30% pongamia biodiesel). Result shows that BSFC of PB100 is highest at all loads from other biodiesels while WCB100 has much lower BSFC than that of PB100. At 25% load the BTE of WCB10:PB10:D80 12.63% is almost equal to the BTE of diesel 12%. The BTE of PB100 and WCB100 are lower than ternary blend and diesel in all loading conditions. The CO and HC emissions are drastically reduced by increasing the percentage of biodiesel NOx emissions for the case of PB100 were highest among the entire biodiesel blend. N. Sreenivasulu et. al.[19] used 100%, 60% crude pongamia oil and 40% diesel (DBD1) and 15% orange oil to 60% crude pongamia oil and 25% diesel(DBD2) as fuel. BTE of engine for diesel, DBD1 and DBD2 are 31.41%, 27.92% and 29.42% respectively. BTE reduced because of high viscosity and lower warming characteristics which lead to poor atomization. HC emission of engine for diesel, DBD1 and DBD2 are 25ppm, 31 ppm and 33 ppm respectively. Emission increases due to poor injection characteristics and improper mixing of blended fuel with air for DBD2 during first phase of combustion. Emissions like CO2 and Co are lesser for DBD2. DBD2 gives better performance and emission as compared to DBD1. Syed Razeequilla et. al. [24] uses Cotton seed oil biodiesel-ethanol-diesel blend [52] in CI engine at different injection pressure. Investigated fuel characteristics and engine performance, significant improvement were observed. Pure cottonseed oil methyl ester exhibits the largest specific gravity of all the blends. Emulsification [30] process is used to produce the biodiesel.

IV. CONCLUSION

Biodiesel received much more attention because of its environmental benefits and economic as well as its availability in the form of natural resources. Biodiesel produced from nonedible oil natural resources can distinguish the use of edible oil for the production of biodiesel. This increases its natural demand in the market of transportation sector and scientists and researchers are now studying possible new sources of nonedible oil of plant based or animal fats. The review presented here concludes that the various feedstock of nonedible plant based and animal fat based oil converted in to biodiesel can be utilized and can be considered as the one of the important source and alternative for diesel fuels. The researches regarding blend of diesel and single biodiesel have been done already. Very few works have been done with the combination of two different biodiesel blends with diesel. From the literature study it is
summarized that the use of dual fuel blend improves the properties like kinematic viscosity, specific gravity, surface tension, cetane number, flash and fire point temperatures with an increase in concentration in the blends.

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