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Better Quality Gas Exhaust Generation from Biodiesel Fuel and its Performance on Diesel Engine

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Abstract. The continuous increasing demand for energy and the diminishing tendency of petroleum resources has led to the search for alternative renewable, sustainable and clean fuel. Biodiesel is best substitute for petro diesel and also most advantageous over petro-diesel for its environmental friendliness. The quality of biodiesel fuel was found to be significant for its successful use on compression ignition engines and subsequently reduced the use of non-renewable fossil fuels. Conventional biodiesel when blend with diesel (B20) it means (80% diesel+20% biodiesel) such as jatropha biodiesel, palm biodiesel produces lesser exhaust gas temperature compared to presently using petro diesel fuel and which led to reduce the global warming potential in our environment by reducing the use of fossil fuel consumption. The use of millions of vehicles across the globe especially in big cities and towns contribute a lot in generating gaseous emissions, hence polluting the environment. These emissions referred to as greenhouse gases are attributed to the cause of global warming. Greenhouse gases such as carbon-dioxide, carbon monoxide, nitrogen oxide, and sulphur causes climatic distraction resulting in drought and environmental adversities on both fauna and flora. It is viewed that combustion of neat biodiesel decreases carbon monoxide (CO) emissions by 46.7%. In addition, biodiesel is non-toxic, making it useful for transportation applications in highly sensitive environments, such as marine ecosystems and mining enclosures. This paper reviews the technologies used for lowering the gaseous emissions temperature, biodiesel quality, and its effects on diesel engines performance such as brake horse power, specific fuel consumption, and brake thermal efficiency. Biodiesel biodegradability, lubricity, stability, and economic importance, have been discussed.

Keywords: Quality biodiesel, palm biodiesel, blend (B20), (80% diesel+20% biodiesel) higher lubricity, Biodegradability

1. Introduction

The concept of biodiesel as an alternative diesel fuel has been gaining great importance worldwide for its good quality exhaust, sustainability and biodegradability. Biodiesel, referred to as mono- alkyl esters are derived from vegetable oils and animal fats, and alcohols of lower molecular weights in the presence of catalysts. Vegetable oils and animal fats are generally insoluble in water, and are commonly regarded as hydrophobic substances belonging to plant and animal kingdom consisting of one mole of glycerol and three moles of fatty acids [1]. Trans esterification reaction is must adopted for the commercial production of

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biodiesel [1–6].Biodiesel production was intended to mainly address the issue of fuel supply security, but recently more attention has been centred on the use of renewable fuels in order to minimize the overall net production of carbon-dioxide (CO_2) from non-renewable fossil fuel combustion. Furthermore, biodiesel does not increase greenhouse gas levels in the atmosphere because of its closed cycle. In other word it is said to be carbon neutral, as biodiesel yielding plants take away more carbon-dioxide than that contributed to the atom-sphere when used as source of energy [7]. However, in a life cycle analysis the overall carbon-dioxide emission was calculated to be decreased by 78% when biodiesel was used as fuel compared to the mineral diesel [5].

2. Biodiesel Purification Technologies

The purification of the crude biodiesel can be technically and most often difficult contributing to the increase in biodiesel production cost. Refined vegetable oils tend to ease the difficulties encountered during separation and purification of the trans esterified products (biodiesel) and provide biodiesel with better physicochemical properties such as viscosity, flash point and densities, etc. However the use of unrefined vegetable oils as raw materials in the production of biodiesel poses great difficulty in the purification processes, leading to low quality biodiesel fuels. Membrane technology was used to purify the crude vegetable oils for further application such as production of biodiesel fuel. Crude vegetable oil membrane refining provides high purity and quality oils [9]. The application of membrane technology in the separation and purification of biodiesel has tremendously reduced water washing application, and have saved a reasonable amount of time and energy consumption [10]. Highly purified biodiesel is necessary to achieve the stringent ASTM-D-6751-03 standard of biodiesel specifications. Production of high quality biodiesel can undoubtedly minimize or erase on the map, the problems of ring sticking, coking and trumpet formation on the injectors, carbon deposits, and thickening and gelling of lubricating oils effects, and also enhance the performance of the diesel engines. The use of biodiesel in diesel engines reduces the emissions of hydrocarbons, carbon monoxide, particulate matter, and sulphur dioxide [8]. Only nitrogen oxide emission increases: this behaviour is due to the oxygen content of biodiesel [7]. This paper reviews the concept of biodiesel purity, quality and its application in diesel engines.

2.1 High Quality Biodiesel

The major focal point for biodiesel high quality is the adherence to biodiesel standard specifications. These standard specifications could either be the American standards for testing materials (ASTM 6751-3) for biodiesel fuel. The technologies applied to refine the feedstock and convert it to fatty acid alkyl esters (biodiesel) determine whether the fuel produced will meet the designed specification standards. The purity and quality of biodiesel fuel can be significantly influenced by numerous factors amongst others include: the quality of feedstock, fatty acid composition of the vegetable oils (virgin oils), animal fats and waste oils, type of production and refining process employed and post-production parameters. Tables 1 and 2 show the international standards specification of biodiesel fuel.

Table: 1 Bio-diesel, B100, specification-ASTM-D-6751-06 [10]

Property	ASTM method	Limits	Units
Flash point	D93	130 min	8C
Water and sediment	D2709	0.050 max	vol.%
Kinematic viscosity, 40 8C	D445	1.9–6.0	mm^2/s
Sulfated ash	D874	0.020 max	mass%
Sulphur	D5453	–	–
S 15 grade	–	15 max	ppm
S 500 grade	–	500 max	–
Copper strip corrosion	D130	No. 3 max	–
Cetane	D613	47 min	–
Cloud point	D2500	Report	8C
Carbon residue 100% sample	D4530[a]	0.050 max	mass%
Acid number	D664	0.50 max	mg KOH/g
Free glycerine	D6584	0.020 max	mass%
Total glycerine	D6584	0.240 max	mass%
Phosphorus content	D4951	0.001 max	mass%
Distillation temperature, atmospheric equivalent temperature, 90% recovered	D1160	360 max	8C
Sodium/potassium	UOP391	5 max combined	ppm

2.2 Physicochemical Properties of Biodiesel Fuels

Table: 2 Physicochemical properties of biodiesel fuels

Vegetable oil methyl ester	Kinematic viscosity (mm^2/s)		Cetane number	Lower heating value (MJ/l)	Cloud point (8C)	Flash point (8C)	Density (g/l)	Sulphur (wt.%)
Peanut	4.9	(37.8 8C)	54	33.6	5	176	0.883	–
Soybean	4.5	(37.8 8C)	45	33.5	1	178	0.885	–
Soybean	4.0	(40 8C)	45.7–56	32.7	–	–	0.880 (15 8C)	–
Babassu	3.6	(37.8 8C)	63	31.8	4	127	0.879	–
Palm	5.7	(37.8 8C)	62	33.5	13	164	0.880	–
Palm	4.3–4.5 (40 8C)		64.3–70	32.4	–	–	0.872–0.877 (15 8C)	–
Sunflower	4.6	(37.8 8C)	49	33.5	1	183	0.860	–
Tallow	–		–	–	12	96	–	–
Rapessed	4.2	(40 8C)	51–59.7	32.8	–	–	0.882 (15 8C)	–
Used rapeseed	9.48 (30 8C)		53	36.7	–	192	0.895	0.002
Used corn oil	6.23 (30 8C)		63.9	42.3	–	166	0.884	0.0013
Diesel oil	12–3.5	(40 8C)	51	35.5	–	–	0.830–0.840 (15 8C)	–

3. Performance of Biodiesel

3.1 Sauter Mean Diameter of Biodiesel Fuel

The Performance of biodiesel can be increased if the Sauter Mean Diameter is the measured, the finer and more homogenous the atomization, the more complete will be physical preparation of the fuel and more easily effective combustion is achieved. The Sauter mean diameter (SMD) is a very common parameter in fluid dynamics used for expressing the fineness of a spray in terms of the surface area of the spray droplets. Studies include the measurement of droplet size using magnesium oxide (Mgo) coating technique and converting into more sophisticated Laser Beam technique [11].

3.2 Droplet Measurement

The experimental set up employed to collect the spray is shown Fig.1 the magnesium oxide coated plates were introduced into the fuel spray injected into open atmosphere with the help of nozzle test apparatus. The distance at which MgO coated plate was introduced and fixed at 90 cm from the nozzle tip. The impressions of the droplets created on the coating of the plate were seen through a 10x inverted microscope choosing different regions on the plate. To minimize the error, two samples (1 and 2), were selected from the spray collected on the glass plate. The number of droplets of different sizes were manually counted viewing through microscope and recorded. The injection pressure was fixed at 200 bar and the fuel samples tested were diesel oil. The experimental set up for determining the SMD consists of a fuel tank, fuel pump, fuel pump plunger, valve, pressure-gauge, high pressure line, fuel injector, stand, MgO coated plate [12-13].

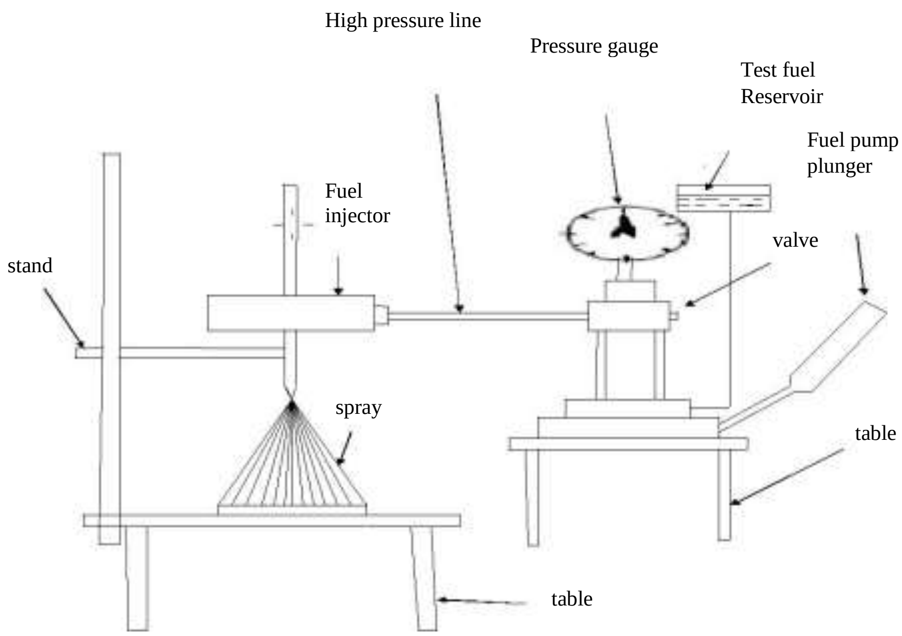


Fig. 1: Arrangement for experimental set-up to inject the fuel and collect on a MgO plate

3.3 Specification of Diesel Engine

The test engine used in this investigation for single cylinder, four-stroke, air cooled, constant speed direct injection diesel engine. The technical specifications of the engine are given. the experimental setup to evaluate the performance and emission of a DI diesel engine fuelled with the test fuels.

Table: 3 Technical specification of the engine

Parameters	Value
Bore, mm	80
Stroke, mm	110
Rated power,kW@1500rpm	3.7
Compression ratio	17.5
Nozzle opening pressure, bar	200
Injection timing, ^{o}CAbTDC	23

3.4 Correlation to Find Brake Horse Power, Specific Fuel Consumption

1. BHP= $V \times I/746$

V= voltage (W), I =current (amp)

2. Fuel Consumption

Wr = X/t × $\frac{\text{specific gravity of fuel}}{1000 \times 3600}$

Where: X= volume of fuel consumed (ml) 1ml=1cm3

t = time taken for X (sec.)

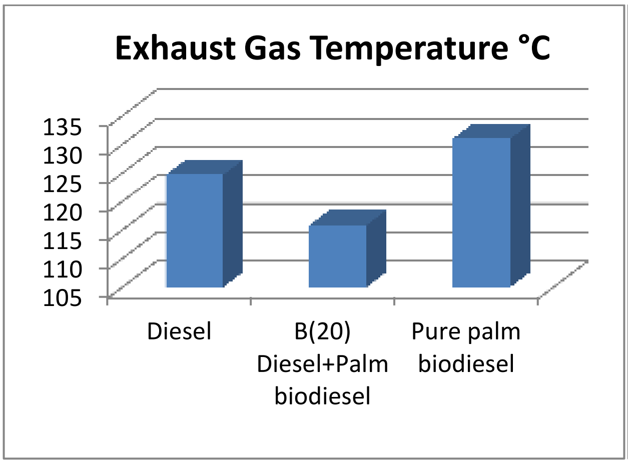
3. Specific Fuel Consumption = fuel consumption/BHP kg/BHP hr

4. Calculation of Brake Horse Power, Specific Fuel Consumption and Exhaust Gas Temperature of Pure and 20% Blended Palm Biodiesel with Diesel

Table: 4 Performance and tastings result of pure diesel fuel, B (20) pure diesel blend + 20% pure palm biodiesel and pure palm biodiesel

Sr.no.	Name of sample	% of Bio Diesel	Flash Point ℃	Fire Point ℃	BHP (HP)	Specific Fuel Cons. Kg/BHP hr.	Brake Thermal Efficiency %	Exhaust Gas Tem.
1.	Diesel	-	51	75	0.2136	0.2613	5.16	124.67
2.	B(20) Diesel+Palm biodiesel	B(20)	45	71	0.2200	1.2322	5.125	115.83
3.	Pure palm biodiesel	-	164	-	0.2169	1.256	5.024	131

5. Results and Comparison



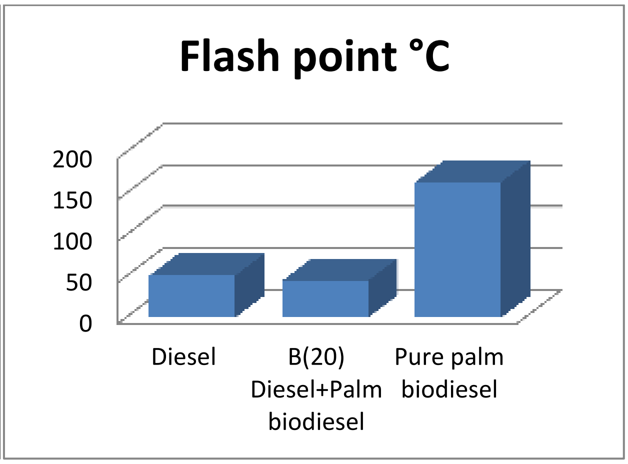


Fig. 2: Flash point of different fuel in ℃

Fig. 3: Exhaust gas temperature of different fuel in ℃

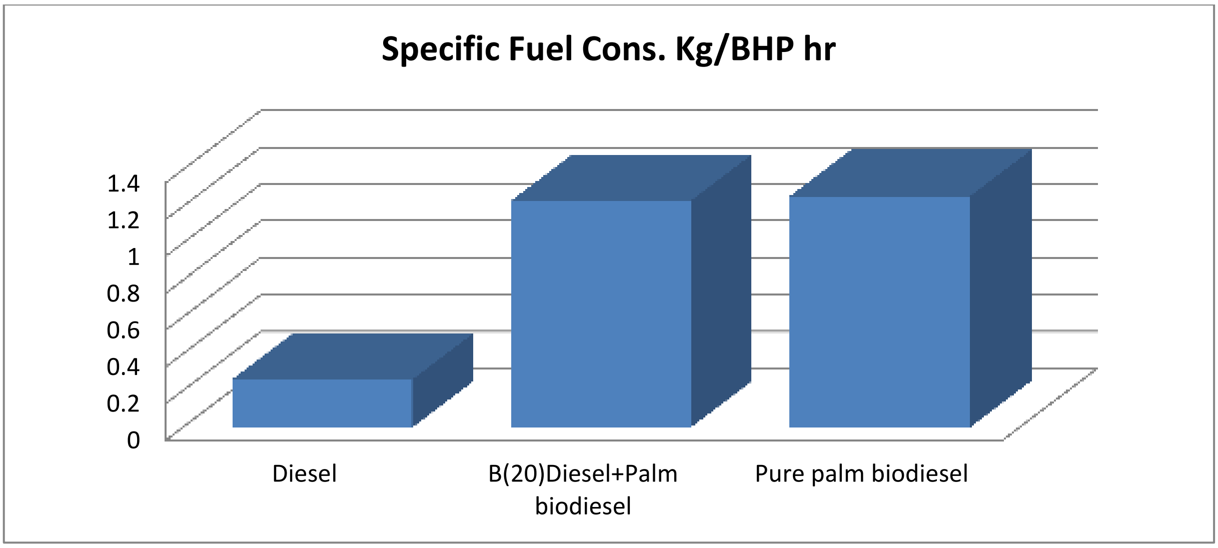


Fig. 4: Specific fuel consumption in kg/BHP hr of different fuel.

5.1 Lower Emissions of Biodiesel

The use of millions of vehicles across the globe especially in big cities and towns contribute a lot in generating gaseous emissions, hence polluting the environment. These emissions referred to as greenhouse gases are attributed to the cause of global warming. Greenhouse gases such as carbon-dioxide, carbon monoxide nitrogen oxide, and sulphur causes climatic distraction resulting in drought and environmental adversities on both fauna and flora. It is that commercial biodiesel fuel has sig-nificantly reduced exhaust emissions 75–83% compared to petro-diesel based fuels. It is also found that combustion of neat biodiesel decreases carbon monoxide (CO) emissions by 46.7%, particulate matter emissions by 66.7% and unburned hydrocarbons by 45.2%. In addition, biodiesel is non-toxic, making it useful for transportation applications in highly sensitive environments, such as marine ecosystems and mining enclosures.

5.2 Advantages of biodiesel

The application of biodiesel to our diesel engines for daily activities is advantageous for its environmental friendliness over petro-diesel. The main advantages of using biodiesel is that it is biodegradable, can be used without modifying existing engines, and produces less harmful gas emissions . Biodiesel reduces net carbon-dioxide emissions by 78% .the advantages of biofuels over fossil fuels to be: (a) availability of renewable sources; (b) representing CO2 cycle in combustion; (c) environmentally friendly; and (d) biodegrade-able and sustainable. Other advantages of biodiesel are as follows: portability, ready availability, lower sulphur and aromatic content, and high combustion characteristics.

6. Conclusion

1. The exhaust gas temperature comes lower when biodiesel blend with pure diesel B (20) which reduces the global warming potential.

2. SMD Sauter mean diameter Chaterstics of biodiesel fuel comes better than diesel fuel which represents better combustion efficiency.

3. The application of membrane technology for the separation and purification of biodiesel was discovered to give better results compared to the conventional technologies.

4. It was observed that high purity and quality biodiesel is necessary to avoid compression ignition engine problems.

5. Biodiesel fuel has been reported to provide a lot of potentials than fossil fuel for instance better quality gas exhaust generation which can lead to reduction in global warming effects and environmental hazards.

6. The performance parameters of biodiesel proved to surpass that of diesel fuel and its application requires no engine modification.

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