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PERFORMANCE AND EMISSION CHARACTERISTICS OF BIOFUEL BLENDS: A REVIEW

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Abstract- The objective of this review is to provide examples of the qualities, performance and biodiesel-emission diesel characteristics mixes used in the burner and CI engines around the world under various situations. Due to the global dilemma with fossil fuels and the associated emission issues, biodiesel is becoming more of a focus as a possible alternative energy source. Unfortunately, it was discovered that the widespread use of biodiesel would burden the food chain and would cause food scarcity. Hence, it was advised to balance its usage by using a blend of biodiesel and conventional diesel, which might still produce a positive greenhouse effect. The use of biodiesel in burner systems not only provides an appealing and more affordable power but also causes fewer issues with higher hazardous pollutants including oxides of nitrogen, carbon monoxide, and particulate matter. This review describes the current state of the numerous studies that had been conducted on these topics. It also discusses the progress that has been made in some of these areas. Based on the analysis, it is evident that this alternative fuel type has the potential to be a desirable renewable alternate energy source for hob systems.

Keywords: Burner, Emission, Combustion, Biodiesel.

1. INTRODUCTION

The cost-intensive rise of alternate forms of energy has led to growing worries about the long-term availability of fossil fuels and their effects on the environment. These sources must be economically feasible and environmentally responsible in order to be used on a broad scale while yet being able to supply the energy needs of a constantly growing global population. Because it has similar characteristics to regular diesel but also has the benefit of being renewable alternate due to its biomass origin, biodiesel is a possible replacement for petroleum-based diesel [1-3]. Little studies have been done on how biodiesel behaves in burners and furnaces, even though the combustion behavior of biodiesel has been the focus of in-depth research globally. The primary purpose of a hob is to deliver a consistent functioning and an appropriate flame pattern under a certain set of operating conditions. One of a burner's operational requirements is the usage of a particular kind of fuel, in this instance biodiesel. Because the degree of unsaturation of the fatty acids varies across various sources, the biodiesels made from various plant oils will have slightly variable molecular structures, such as carbon-chain lengths, hydrogen-to-carbon ratios, and oxygen contents [4-7]. These fuels are more readily available in burners than in other combustion devices. However, when opposed to typical petroleum-based diesel, using low quality of fuel in the hob system causes problems since it emits more dangerous gases including monoxide, oxides of nitrogen, and particles [8-11].

2. BIODIESEL AS ALTERNATIVE FUEL

Biodiesel is a type of renewable energy made of from derived from animal matter resources or living plants, biodiesel complies with ASTM D6751 standards and is generally comparable to EN 14214, a European standard, and CAN/CGSB-3.524, a Canadian national standard. Triglycerides, which can be found in a variety of sources like vegetable oils, animal fats, and algae are used to make biodiesel. Soybean oil is the most popular source of feedstock for biodiesel in the United States [5]. Canola oil, which is primarily used in Europe, and palm oil, which is primarily used in Asia, are examples of other types of oils that can be used.

Due to several variables, biodiesel and other types of biofuels are evolving swiftly, such as their capacity to use renewable resources energy ("unlike fossil fuels"), when as opposed to crude of oil, and environmental familiarity. The production of biodiesel involves a process called trans esterification, which results in fatty acid alkyl esters by breaking the ester bonds in triglycerides in the presence of basic (NaOH or KOH) or acid (H_2SO_4) catalysts (such as methanol or ethanol). Glycerol and biodiesel are the byproducts of this process [12]. In order to produce power, biodiesel can be combined with other fuels or used in 100% "neat" form in diesel engines. However, because Biodiesel has a greater cetane value and higher flash. The ratio of biofuel that is mixed or blended depends on the end use.

Table 1. Summary of biodiesel specifications [13]

Property	Test Approach	Grade No.1-B S15
Sulfur	D-5453.0	0.0015 (15)
Cold soak filterability	D-7501.0	200.0
Mon glycerides	D-6584.0	0.40
Magnesium and Calcium	EN-14538.0	5.0
Flash index (closed cup),	D- 93.0	93.0
Methanol level	EN-14110.0	0.2
Flash index	D-93.0	130.0
Sediment and water,	D-2709.0	0.05
viscous	D 445.0	1.9-6.0
Sulfuric ash	D 874.0	0.02
Corrosion of Copper Strips	D 130.0	No. 3
CN	D 613.0	47.0
Cloud Index	D 2500.0	Reveal
C Remainder	D 4530.0	0.05
pH value	D-664.0	0.5
Pure Glycerin	D-6584.0	0.02
Complete Glycerin	D-6584.0	0.24

With fossil fuels, there are several blends available, such as B-20, where B is biodiesel and the number denotes the blending proportion. A B-20 blend, for instance, would contain 80% fossil fuel and 20% biodiesel. Only engines that have been adapted and have parts that are compatible can run on neat (B100) biodiesel. Plastic parts and Rubber are known to disintegrate in biodiesel because biodiesel esters are effective solvents. It ought to be mentioned the fact that qualities derived from biodiesel vary depending on the primary component used. But only fatty acid alkyl esters that meet the aforementioned requirements are referred to as biodiesel. In light of this, this evaluation evaluates biodiesel that complies with these requirements [14].

3. PROPERTIES OF BIODIESEL

3.1. Kinematic Viscosity

Kinematic viscosity, which essentially gauges how thick the fuel would be, is the liquid's reluctance to flow. Low viscosity might not allow for complete combustion, and viscosity in excess would cause the fuel injection system to close. The measurement method and the feedstock, however, may affect viscosity. According to ASTM D445 "Kinematic Viscosity Test for Clear and Transparent Liquids", pure biodiesel fuel produced from a variety of feedstocks has a viscosity that ranges from 1.9 to 6.0 mm^2/s. According to reports, biodiesel has a higher viscosity than fossil of diesel (Table 2).

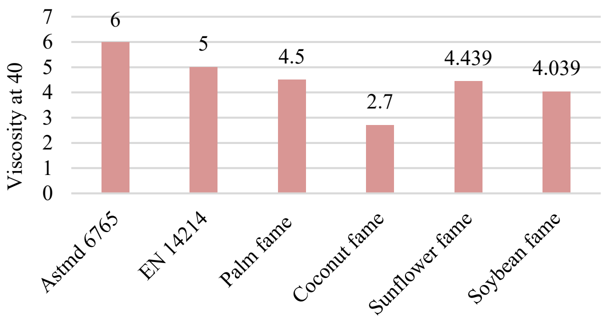

Figure 1. Biodiesel fuel kinematic viscosity values [15]

In reality, one of the main purposes of Tran's esterification is to make vegetable oil less viscous; the resulting biodiesel has far less viscosity than the initial triglycerides. In general, biodiesel becomes more viscous as the rise of double bonds within the carbon chains [15]. The kinematic viscosity values of different types of bio-diesel fuel are shown in Figure 1.

3.2. Calorific Value (CV)

As measured by ASTM D240, CV is additionally referred to as the heating value in writing. An indication of the fuel's energy content is the quantity of energy generated when a familiar volume of fuel burns completely. Because of its increased oxygen concentration, biodiesel often has such a lower heating value than normal diesel. A higher limit of 45 MJ/Kg applies to almost all conventional fuels. While the minimum limit for the maximum heating value stated for biodiesel is 35 MJ/kg [16].

3.4. Flash Point

The flash point refers to the temperature at which a fuel will burn when exposed to a flame or spark. It varies depending on the type of fuel and the blend. The flash point is the minimum temperature at which a fuel can be ignited. To improve combustion, a lower flash point is desired. Yet, the fuel is more transportable safe. Because of the greater flash point. Typically, biodiesel has a greater flash point than regular diesel. The flash point of biodiesel is approximately 110-180 °C, whereas that of regular diesel is approximately 55-60 °C. The high flash point is due to unsaturated chains C 18:1 and longer [17].

3.5. Cetane Number

The ASTM D613 test method measures CN, which represents the fuel's ignition quality after it is fed to a diesel engine (Standard Test Procedure for Diesel Fuel Oil the Cetane Index). The Cetane Index measures the timing (or ignition delay) of the combustion chamber of a diesel engine. The higher the CN value, the better the fuel performs and the quicker it ignites. This suggests that the fuel will ignite more quickly if the CN is higher. Higher CNs are typically found in longer, saturated carbon chains. As a result, the CN will have a higher hydrocarbon content than the feedstock. For instance, compared to other feed stocks, biodiesel produced from animal fat will have a higher CN [18].

3.6. Both the Cloud and Pour Points

The both the cloud and pour points of biodiesel fuel are two crucial physical characteristics. The pour, however, in which the temperature a liquid begins to harden and lose its fluidity [10]. The ASTM D97 (Pour Point of Petroleum Products Standard Test Protocol) and D5950 or D5949 are used to measure pour point [10]. Saturated fatty acid content is correlated with cloud and pour points. Generally speaking, increased saturated fatty acid concentrations raise the cloud and pour points. Biodiesel typically compared to ordinary diesel, has higher cloud and pour points. B-100's cloud and pour points have values between 15 and 16 °C [19].

3.7. Lubricity

A crucial characteristic of biodiesel is lubricity, which provides it an edge over conventional fuel. The property of a substance to lubricate is known as lubricity. Lubricity issues have been observed to be resolved by adding 2% or less of biodiesel can replace regular diesel [39]. The EPA mandated the removal of sulfur (an addition that improved lubricity) from regular diesel makers in 1993 and again in 2006 when extensive hydro treating as necessary to comply with the US EPA's 15 ppm sulfur maximum rule. As a result, the fuel's ability to lubricate the engine's components were severely diminished. According to Muoz, et al. [20], including biodiesel could help reverse the harm caused by sulfur removal. Assessing how well a small film of liquid can prevent two metal surfaces from severe corrosion, viscosity.

3.8. Emissions

Utilizing similar criteria, such as CO content, smoke concentration, and particle matter, and CO_2 content, emissions data from the combustion of biodiesel have been compared to those from conventional diesel (Table 2). When compared to regular diesel, biodiesel emits less CO_2, CO, and smoke, as well as less CO. In actuality, particle emissions for B-100 were reported to be 33% lower than those for ordinary diesel. In addition, levels of CO and CO_2 were 10% lower than with standard fuel. However, when utilizing biodiesel mixes, this ratio may change [21].

Table 2. Diesel and biodiesel combination emissions comparison [21-24]

Emission	Diesel	Blend biodiesel 100%	Blend biodiesel 20%	Blend biodiesel 5%
CO_2	12.9% 173.6 3892.5*	- 172.9 -	12.9% - 3664.2*	- - 3488.7*
CO	30 0.153 3.6*	- 0.067 -	32 -2.8*	- - 2.9*
Particulate Matter Concentration	12.9±0.9 14.92	8.6 ± 1.3 -	12.5±0.9 13.38	- -
SO_x	96 6.8*	- -	77 0.8*	- 1.4*

3.9. Density

Typically, viscosity and cetane number are used to determine density. Because the biodiesel-diesel mixtures are denser than regular diesel, the size of the fuel droplets is enhanced. A lower density value will increase the efficiency of atomization and the growth of the air-fuel proportion. By adjusting the mass of fuel infusion, the density value alters the burning quality. Because of the high density, more gases, notably NOx particulate matter, are discharged. Depending on the source and production method, biodiesel density varies, as seen in Figure 1. The density of coconut biodiesel is lower (807.3 kg/m^3) than that of soybean biodiesel (931 kg/m^3) [25].

3.10. Performance

In general, the performance of biodiesel made from various oils is comparable to that of diesel fuel. The combustion temperature increases as the equivalent ratio increases. It is evident from the experimental studies that all fuel types raise the overall combustion temperature by increasing the exhaust temperature in conjunction with an increase in the equivalent ratio of the fuel-air mixture. The additional fuel in the mixture, which releases a lot of heat, is to because for this. As the amount of biodiesel in the mixture rises, so does the exhaust temperature. This is due to the fact that biodiesel has a larger oxygen concentration than diesel, which causes complete combustion and, as a result, a higher combustion temperature [26].

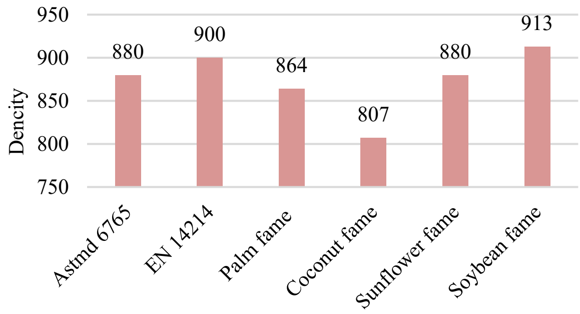

Figure 2. Biodiesel fuel density values [26]

Table 3. A few characteristics of biodiesel fuel blends [27-29]

Properties	Diesel without add	Blend biodiesel 100%	Blend biodiesel 20%	Blend biodiesel 5%
Viscosity Level	2.0 3.5 3.061 4.31 2.72 2.4 2.5	4.2691 4.89 5.75 11* 6.17 4.92	- 3.75 - - 3.21 2.74	-3.56 4.45 -2.92 2.48
"Flash index"	69 53 71.5 59	120 168* - 111	82 - - 67	74 57 - 64
CN	42.6 50.9 46	51.5 56*	52.2–52.3*	- 51.5*
Cloud index	0 2 -	3 - -	0 - -	0 (24 to 28)
Sulfur Level	15.0-500.0 300.0 ppm 3.590-12.290	- - 10.940-11.690 -	- - 0.070	- - -
Lubricity	0.83	0.72	-	-
KOH	-	0.275	0.057	0.008

3.11. Advantages of Utilizing Biodiesel

1. Using biodiesel as an alternative to diesel fuel has some benefits, including:
2. Renewable energy (vegetable oils or animal fats sources).
3. Compared to diesel fuel, toxicity is lower.
4. Reducing the impact on the environment because it ages more quickly than diesel fuel.

5. Carbon monoxide, particulate matter, and unburned hydrocarbon emissions are reduced.
6. Reduced health risk as a result of decreased emissions of carcinogens.
7. There are no sulfur dioxide emissions.
8. Increased flash point (120 C minimum).
9. A large range of blending ratios with diesel is possible.
10. Excellent lubricating qualities.
11. Without modification, can be used in oil burners and diesel engines.

3.12. Disadvantages of Utilizing Biodiesel
1) Variations in Biodiesel Quality
2) Insufficient for usage in cold climates
3) Food Scarcity
4) Increasing Fertilizer Use
5) Engine Clogging
6) Making Biodiesel from Petroleum Diesel
7) Water Scarcity

4. ALCOHOL

4.1. Methanol
Methanol is a well-known alcohol that can be made from wood or biomass through a procedure called partial oxidation. Liquefied natural gas is processed to create methanol for commercial use. Methanol primarily comes from fossil sources [28].

4.2. Ethanol
Ethanol is a significant renewable fuel. It is typically produced by fermentation of carbohydrates (most often corn in temperate countries and sugar cane in tropical regions) and, more recently, cellulose. Glucose sugar serves as the foundation for ethanol regardless of the source. Ethanol is available in two forms: pure E-100 and blended fossil fuel at any ratio. The number that comes after the prefix E, like with biodiesel, indicates the percentage of ethanol in ethanol blends. E85 and E10 are the most popular blends in the US. [29]. the differences in the characteristics of ethanol and methanol fuel are shown in Table 4.

Table 4. Chemical characteristics of methanol, ethanol, and diesel [29]

Properties	Methanol	Ethanol	Diesel
Vaporization energy (kJ/kg)	1162	918.42	243.0
Temp of boiling (°C)	65.0	78.0	180-370
Temperature for automatic ignition (°C)	463.0	420.0	~300.0
Low calorie content (MJ/kg)	20.10	26.9	42.50
Proper air-to-fuel stoichiometry	6.470	9.01	14.30
Flash index (°C)	12.0	13.0	65.0-88.0
RON	136.0	129	20.0-30.0
Cetane index	3.80	5-8	40.0-55.0

5. BIODIESEL AND ITS ALCOHOL BLEND
Fuels made from biodiesel and its alcohol blend are viewed as potential replacements for present fossil fuels. The fuel's physical properties are a main determinant of its quality. Bio-diesel and alcohol blend fuels need to have their actual properties defined, strict processes are utilized in observation and measurement to determine the acid value, the cetane index, the viscosity, the density, and the flash point. The utilization of these discovered qualities in any mathematical simulation for additional research is quite advantageous. According to the findings of one study, while blending biodiesel with mineral diesel, Alcohol lowers the mixture's viscosity and density, making it easier to work with. On the other hand, a considerable rise in Cetane due to elevated levels of alcohol in the fuels made from biodiesel blends. Nonetheless, alcohol-blended fuels like Bio - diesel still have qualities that match the criteria.

6. CONCLUSIONS
The review of the performance and emission characteristics of biodiesel use in engine or burner systems indicated that this form of substitute fuel can be an appealing alternative that is the renewable energy source for diesel burner systems. The performance and emissions of the hob can be significantly impacted by the physical and chemical characteristics of biodiesel. The hob design should be compatible with the properties of the biodiesel for improved performance and emission. The quest for low-cost feedstock and production methods for high-quality biodiesels must not only take into account economic variables but also place a strong emphasis on long-term ecological and environment-related issues. It is possible to lessen the issues associated with increasing harmful emission levels of nitrogen oxide, carbon monoxide, and particle matter. The addition of oxygenates generally results in an improvement in the emissions profile. The final blend's cetane number and lubricity qualities both increase when biodiesel is added to diesel fuel. Moderate methanol addition to diesel enhances the blend's cold-flow characteristics while lowering the cetane rating. The quality of the final fuel mix can be improved by adding biodiesel to methanol-diesel blends in order to counteract cetane decrease and improve methanol's miscibility in diesel fuel.

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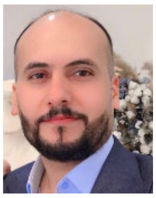

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