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"A REVIEW ON THE PERFORMANCE AND EMISSION CHARACTERISTICS OF A DIESEL ENGINE"

Md Zahid [1], *Gurjeet Singh* [2]

[1,2] *Department of Mechanical Engineering, IES College of Technology Bhopal (M.P.)-India-462001*

ABSTRACT

For decades, the globe has relied entirely on fossil fuels to meet its daily energy needs. Sustainable characteristics and eco-accommodating nature of biodiesel has made it most well-known among numerous other options to petroleum goods. Experts and academics have now concluded that biodiesel combined with higher alcohol content can be a suitable alternative in this case. The finest and most appropriate substitutes for depleting natural resources are thought to be biodiesel, higher alcohol, and gaseous fuels. These alternative fuels work together to reduce harmful exhaust emissions in addition to helping with improved engine performance. According to earlier research, biodiesel, increased alcohol, and gaseous fuels can all aid in enhancing a diesel engine's performance and reducing its harmful exhaust emissions. However, biodiesel is insufficient in lowering the disastrous emissions of nitrogen oxides, which can be attributed to its increased oxygen content. Similarly, gaseous fuels lack the capacity to reduce harmful carbon monoxide emissions due to their low oxygen content, and greater alcohols are ineffective at reducing toxic hydrocarbon emissions due to their lower cetane number. In the current study, an attempt is made to fuel a diesel engine using rice bran methyl esters (biodiesel), n-butanol (higher alcohol), and biogas (gaseous fuel) in order to get around this problem of reducing the harmful exhaust emissions from the diesel engine.

Key Words: Biodiesel , Emissions, Energy.

I. INTRODUCTION

Today's world faces a terrible threat from pollution, which is not limited to metropolitan areas but is also spreading to rural areas. Decrepit cars are prohibited in New Delhi, India, because the main cause of the pollution is the growing number of diesel engines on the road. The use of petroleum products in CI engines pollutes the environment and depletes fossil fuels at a startling rate. The majority of diesel engine specialists have been attracted by this proof and are looking for alternative fuels that can restore the current diesel fuel supply. Biodiesel made from vegetable and animal fats, higher alcohols like butanol, propanol, and pentanol, and gaseous fuels like compressed natural gas, natural gas, biogas, and liquefied petroleum. These have drawn the interest of investigators in recent lustrums.[1]

While gaseous fuels are preferred as an alternative fuel because of their unparalleled qualities, such as a higher auto ignition temperature and a homogenous air-fuel mixture, biodiesel and higher alcohols are oxygenated fuels that help with full combustion of fuel and reduce the deadly gases coming out of the diesel engine's tailpipe.[2] The following chapter examines the separate effects of biodiesel, n-butanol, and biogas on a diesel engine through a review of the literature from highly regarded publications and technical international conference papers.

1.1 Impact of different factors on the generation of biodiesel

Fatty acids from vegetable and animal fats can be consumed to create biodiesel, a fuel. It has been one of the most sought-after fuels as a diesel substitute because, according to many researchers, its qualities are very similar to those of diesel fuel, making biodiesel a suitable fuel substitute that can be used in diesel engines with negligible or no engine

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modifications. In comparison to regular diesel, biodiesel has a higher cetane number, includes 10-12% oxygen by weight, and is free of sulphur and aromatics.[3]

These characteristics help to reduce harmful emissions like CO and HC. Fuel characteristics for biodiesel made from various vegetable oils are shown in Table 1.1. It shows that the biodiesel made from the majority of the oils has properties that are much more similar to diesel, such as density, viscosity, cloud point, pour point, fire point, cetane number, and calorific value. As a result, it may be used in diesel engines. The table also shows that practically all vegetable oils have densities that are quite similar to diesel oil. The viscosity of most vegetable oils, with the exception of a few number, is within the range of diesel oil. With a few exceptions, all vegetable oils have a greater flash point than diesel oil. It is impossible to analyse Fire Point because the majority of scholars do not mention it.[4]

The catalyst, reaction temperature, stirring rate, and mole ratio are some of the variables that affect the generation of biodiesel. The values of these parameters for biodiesel made from different oils are displayed in Table 1.2.

Table 1.1 Properties of various materials used for production of Biodiesel

Oil used	Density (kg/m^3)	Viscosity (m^2/s)	Flash Point (^{O}C)	Cetane Number	Higher Calorific Value kJ/kg	Cloud Point (^{O}C)	Pour Point (^{O}C)	Fire Point (^{O}C)	Ref. No.
Mahua oil	899	37.18	238	NM	36372	14	15	243	22
Rice Bran Oil	896.4	8.05	173	NM	39030	NM	NM	NM	92
Waste Cooking oil	883	4.94	161	57.1	40111	NM	1	NM	81
Jatropha Oil	870	4.1	180	NM	39900	NM	NM	NM	84
Pine Oil	875	1.3	52	11	42800	NM	NM	NM	93
Mustard Oil	938	6.5	105	NM	NM	6	-13	NM	86
Neem Oil	871	4.63	NM	53.5	41000	NM	NM	NM	87
Cottonseed Oil	864	4.14	NM	52	36800	NM	NM	NM	87
Turpentene Oil	920	2.5	38	38	44400	-15	-23	NM	94
Palm Oil	851	8	270	NM	NM	18	6.7	NM	95
Rapeseed Oil	884	5.5	138.5	51	38200	NM	NM	NM	96
Linseed Oil	852	3.95	151	NM	NM	3.17	-6.25	NM	89
Hazelnut oil	872	4.51	168	53.35	NM	-11	-17	NM	90
Sunflower Oil	882	4.04	179	51.25	NM	-14	-16	NM	90
Castor Oil	896	12.59	124	NM	37931	NM	NM	NM	91
Diesel Oil	820-860	3.5-5	60-80	40-45	42000	-15 to -5	-33 to -15	52 to 96	98

Table 1.2 Parameters for Biodiesel Production

Oil Used	Temp. (^{O}C)	Molar Ratio	Catalyst Type	Stirring Speed(R.P.M)	Time (min)	Ref. No.
Mahua Raw oil	60	NM	KOH	500	60	22
Rice Bran Oil	65	6:1	CH3OK	NM	60	79
Waste Cooking oil	100	NM	NM	NM	30	81
Jatropha Oil	60-65	6:1	NaOH	NM	NM	71

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Euclyptus Oil	65	NM	CH3OK	NM	60	85
Karanja Oil	60-80	10:1	KOH	NM	NM	77
Mustard Oil	55	NM	NaOH	600	90	86
Neem Oil	55	NM	NaOH	NM	60	87
Cottonseed Oil	55	NM	NaOH	NM	60	87
Palm Oil	65	NM	KOH	700	120	88
Rape Seed Oil	80	NM	$Ca(OH)_2$	60-360	180	80
Linseed Oil	40-60	6:1 to 9:1	NaOH	750	15-180	89
Hazelnut oil	60	6:1	KOH	NM	120	90
Sunflower Oil	60	6:1	NaOH	600	90	90
Castor Oil	80	NM	NaOH	500-600	120	91

1.2The impact of the molar ratio

The molar ratio has a fundamental impact on the yield of alcohol ester to vegetable oil. Several analysts have discovered that the mixing of excess methanol in glycerin and the increase in the rate of trans esterification with a rising molar ratio of methanol to oil make it more difficult to separate methyl esters from glycerin [5-6]. With an initial rise in the molar ratio of alcohol to oil, absorption of free fatty acids results in an increase in the reaction product [7]. When the molar ratio rises from 6:1 to 18:1, the biodiesel yield rises from 48.12% to 99.75%.

1.3 Impact of catalyst type and quantity

Most of the researchers discovered that more viscous fuel is recovered with an increase in catalyst quantity. Consequently, 6.0% by weight of oil is the optimal catalyst quantity [8]. Due to the use of several recommended catalysts, it was also discovered that the reaction products contained a relative amount of unsaturated fat esters [9]. An increase in catalyst concentration from 2% to 12% was also found to increase the transformation rate. The conversion efficiency barely decreased as the amount of catalyst increased [10].

1.4 Reaction temperature's impact

The reaction's temperature also plays a crucial role in determining the biodiesel yield level. The ideal temperature of response for the transesterification process to produce biodiesel is 65°C [11]. The response rate is shown to be faster at high temperatures than at low ones. The concentration of the basic product decreases as the process temperature rises [12]. Additionally, increasing the process temperature increases the production of biodiesel by over three times. In addition to consuming more energy, higher reaction temperatures necessitate higher operating pressures to prevent methanol evaporation [13–14]. As the reaction temperature rises above 55°C, several investigators discovered that the ester yield decreases [15].

1.5 Stirring rate's impact

Some researches have discovered that the transesterification response is insufficient when stirring at a pace of 60 rpm for a specific amount of time. After three hours, the biodiesel yield at 270 rpm reaches 90%. If the mixing rate is increased to 360 rpm, the biodiesel yield remains unchanged, indicating that 270 rpm is the optimal mixing pace for the transesterification reaction [16]. Although most investigators discovered that the yield of methyl esters increased with increasing agitation speed, the highest yield was achieved at 700 rpm [17].

1.6 Free Fatty Acids percentage

Fuel quality, yield rate, and properties are all impacted by free fatty acids. Jatropha and Karanja oils had respective contents of 2.7% and 1.7% free unsaturated fats [18]. Consequently, methyl oleate, methyl stearate, methyl a-linolenate, methyl palmitate, and methyl linoleate should all be included in the response's methyl ester product. The esterification of free unsaturated fat and the transesterification of triglycerides are the two processes that produce methyl oleate [19]. The chemical structures of several fatty acids are displayed in Table 1.3.

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Table2.3Chemical structure of fatty acids [97]

Fatty Acid	Systematic Name	Structure	Formula
Lauric	Dodecanoic	$C_{12}H_{24}O_2$	$C_{12}H_{24}O_2$
Myristic	Tetradecanoic	$C_{14}H_{28}O_2$	$C_{14}H_{28}O_2$
Palmitic	Hexadecanoic	$C_{16}H_{32}O_2$	$C_{16}H_{32}O_2$
Stearic	Octadecanoic	$C_{18}H_{36}O_2$	$C_{18}H_{36}O_2$
Arachidic	Eicosanoic	$C_{20}H_{40}O_2$	$C_{20}H_{40}O_2$
Behenic	Docosanoic	$C_{22}H_{44}O_2$	$C_{22}H_{44}O_2$
Lignoceric	Tetracosanoic	$C_{24}H_{48}O_2$	$C_{24}H_{48}O_2$
Oleic	cis-9-Octadecenoic	$C_{18}H_{34}O_2$	$C_{18}H_{34}O_2$
Linoleic	cis-9,cis-12-Octadecadienoic	$C_{18}H_{32}O_2$	$C_{18}H_{32}O_2$
Linolenic	cis-9,cis-12,cis-15-Octadecatrienoic	$C_{18}H_{30}O_2$	$C_{18}H_{30}O_2$
Erucic	cis-13-Docosenoic	$C_{22}H_{42}O_2$	$C_{22}H_{42}O_2$

II. CONCLUSION

- Compared to diesel fuel, biodiesel, n-butanol, and biogas were found to have greater BSFC and BSEC.
- For all other fuels, BTE and BP were lower than those of standard diesel.
- When compared to pure diesel, NOx emissions were greater for biodiesel fuel blends but showed a declining trend for n-butanol and biogas.
- Compared to conventional diesel, it was found that CO_2 and O_2 exhalations increased with biodiesel and n-butanol fuel blends, but decreased with biogas-fueled engines. Emissions of CO were in direct opposition to those of CO_2 and O_2.

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