



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 1, January 2024

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

Effect of Operating Parameters and Antioxidant Additives with Pine Oil-Biodiesel to Improve the Performance and Diminishing the Emissions in a Compression Ignition Engine

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ABSTRACT: The use of biodiesels is growing daily in the modern world. In addition to being a clean fuel and a sustainable energy source, biodiesel has been shown to be an effective diesel replacement. In the modern world, biodiesel gradually came to be recognized worldwide. This study focuses on mixtures of diesel and pine oil. In a direct injection diesel engine, a 20% blend of pine oil and diesel is made and tested at the standard injection timing of 23⁰bTDC. POME20 has a BTE and BSFC of 32.5% and 0.26 kg/KWh, respectively. Additionally, POME20 is tested at 27⁰bTDC, advanced injection timing. At 27⁰bTDC, the BTE of POME20 is 34.25%, and its NO_x emissions are 2230 ppm. POME20 at advanced injection timing had superior BTE than POME20 at regular injection timing, according to the results. However, it is discovered that at advanced injection timings, NO_x emissions are considerable. NO_x emissions decreased when greater alcohol 1-butanol was introduced to POME20 at an advanced injection timing of 27⁰bTDC. As 1-butanol concentration rose, NO_x emissions dropped. Compared to POME20 at advanced injection timing, NO_x outflow dropped by 5.26% and 8.68% for POME20-1B20 and POME20-1B30, respectively. Blends with increased alcohol content have lower BTE. When POME20-1B20 and POME20-1B30 were compared to POME20 at advanced injection timing for peak pressure condition, BTE reduced by 2.74% and 4.65%, respectively.

KEYWORDS: Pine oil methyl ester, IC Engine, 1-butanol, standard & advanced injection timing.

I.INTRODUCTION

The quest for sustainable and eco-friendly fuel alternatives has become increasingly important in the wake of rising environmental concerns and the depletion of fossil fuel resources. Biodiesel, as a renewable and biodegradable fuel, has gained significant attention in this context. Derived from natural oils and fats, biodiesel has been identified as a viable alternative to conventional diesel fuel. Among various sources for biodiesel production, pine oil, derived from the distillation of pine trees, offers an environmentally benign and cost-effective option. Pine oil biodiesel exhibits several favorable properties, such as high cetane number and low sulfur content. However, its broader application is hindered by certain limitations, including high viscosity, lower volatility, and cold flow issues, which can affect engine performance and increase emissions. To overcome these drawbacks, the use of additives is considered an effective strategy. 1-Butanol, a four-carbon alcohol, emerges as a promising additive due to its superior blending properties and ability to enhance fuel characteristics. The incorporation of 1-butanol in pine oil biodiesel could potentially improve fuel atomization, reduce viscosity, and enhance combustion efficiency. Moreover, 1-butanol's oxygenated nature can lead to cleaner combustion, thereby reducing harmful emissions. K.Madhu babu et al. [1] blends of diesel, pine oil, biodiesel, and decanol were used in the tests. Decanol was prepared by combining it at volumes of 10%, 20%, and 30%, while diesel was retained at 50% throughout. The concentration of biodiesel was varied in relation to the decanol. In this analysis suggests using a 30% blend of diesel (50%), biodiesel (20%), and canola (30%) to reduce emissions and enhance performance without altering the compression ignition engine. Veerendar et al. [2] when Palm oil at 20% mixed with 80% diesel is injected with higher alcohol 1-butanol at an advanced injection timing of 27⁰ bTDC, NO_x emissions decrease as 1-butanol concentration rises. Blends with increased alcohol content have lower BTE. The study's final conclusion was that, when diesel is added with butanol, the emissions are lower than when diesel alone.

N.S.Ramakrishna et al. [3] a standard direct injection diesel engine with 23⁰bTDC is used to prepare and test a 20% jackfruit oil and diesel combination. Moreover, accelerated injection time of 27⁰bTDC is tested for JOME20. The findings demonstrated that, in comparison to JOME20 at regular injection time, JOME20 with advanced injection timing has improved BTE. However, it is discovered that at advanced injection timings, NOX emissions are elevated. NOX emissions reduced as 1-butanol concentration rose when higher alcohol 1-butanol was introduced to JOME20 at an advanced injection timing of 27⁰bTDC. This paper investigates the synergistic effects of blending pine oil biodiesel with 1-butanol on fuel properties, engine performance, and emission characteristics. The effects of 1-pentanol and 1-butanol as additives with Calophyllum Inophyllum biodiesel were evaluated by Nanthagopal et al. [4]. We saw research by Jinlin Xue et al [5] on the effects of biodiesel in CI engines. A thorough analysis is conducted on the effects of biodiesel on engine power, economy, and discharges, including both directed and undirected outflows. Utilizing biodiesel leads to a significant reduction in PM, HC, and CO emissions as well as an increase in fuel consumption and NOx emissions. The engine's power decreased due to the biodiesel's high thickness and loss of calorific value. The content of unsaturated mixtures in biodiesel may have a significant impact on emissions of NOx. However, produced more NOx emissions when compared to pure diesel, with increases ranging from 5.58% to 25.97%. Using blends of diesel and rice bran biodiesel, Subbaiah G.V. et al. [6] investigated the impact of an antioxidant on the performance of a diesel engine. N, N0-diphenyl-1, 4-phenylenediamine (DPPD) is used in these studies as a cancer-prevention agent for the blends of diesel and rice wheat biodiesel. For the mixes with the expansion of cell reinforcement, the brake thermal efficiency climbed to 3.54%, the brake specific fuel consumption was reduced by 1.81%, and the fume gas temperature was reduced by a maximum of 2.53%. B10 and B20 have respective EGTs that are 6.8% and 11.4% greater than diesel fuel. The performance, combustion, and emission studies of blends of n-octanol and mustard oil biodiesel in diesel engines were investigated by Y.Devarajan et al. [7]. 10%, 20%, and 30% of n-octanol were added to pure methyl ester mustard oil biodiesel in order to boost the oxygenation buffering that lowers emissions and speeds up combustion [8]. Blends of octanol and mustard oil biodiesel are more thermally efficient than straight biodiesel. The oxidation impact of n-octanol and higher energy density both improve the fuel's oxidation capability and lower emissions of CO, HC, and NOX. The impact of combining n-Butanol with Jatropa Methyl Esters (JME) on compression ignition engines was examined by Kumar N. et al. [9]. The amount of n-butanol added ranged from 5% to 20%. Comparing JOME 100% to other n-butanol blends, greater emissions such as CO and NOx as well as smoke opacity were produced [10]. This research contributes to the ongoing efforts in developing sustainable alternative fuels, and the findings have significant implications for the automotive industry, policy makers, and environmentalists seeking to reduce the environmental impact of transportation fuels.

II. MATERIALS AND METHODS

A little denser and thicker crude pine oil is obtained from the pulp of the pine seed. When it is directly injected into the engine, it results in poor fuel atomization, choked injectors, stuck piston rings, and prolonged ignition delay. Inadequate fuel atomization causes an increase in BSFC to produce the same power output as diesel, but it also causes an erratic rise in HC and soot emissions [11-14]. Engine vibration might result from detonation brought on by an increase in ignition delay. Therefore, before adding crude pine oil to the engine's combustion chamber, its thickness should be decreased [1]. Like other vegetable oils, free fatty acids (FFA) are present in crude pine oil. These free fatty acids could have a saturated character or not. Vegetable oils contain the acids linoleic acid, oleic acid, carboxylic acid, and steric acid. A same proportion of saturated carboxylic acid is present in crude pine oil. Vegetable oils can be made thinner using a variety of methods, including transesterification, preheating, mixing with diesel, and making micro emulsions. Transesterification is the method most frequently employed to lessen the thickness of vegetable oils among those mentioned above. The process of transesterification involves changing vegetable oil triglycerides into methyl or ethyl esters of fatty acids. The amount of methanol or ethanol, the kind of catalyst, the amount of free fatty acids, the reaction temperature, and the amount of water all affect this process [15-18]. The necessary biodiesel will be produced by base catalysed transesterification since the chosen crude pine oil contains more than 0.5% FFA by weight. A rise in FFA in crude oil causes soap to develop during the esterification process, which could hinder the separation of glycerol and biodiesel. For a significant volume of oil to be produced, transesterification requiring both base- and acid-catalyzed catalysts must be completed. Saturated fatty acids are removed by the acid esterification process, whereas unsaturated fatty acids are removed by base catalyzed esterification. Some more steps we followed for to make biodiesel, those are **Esterification using acid catalysts** [19-24]; **Esterification using base catalysts** [25]; **Washing and Purification** [26-30]; **Fuel Properties** [31-35].



Table.1. Fatty acid composition of pine oil methyl ester

Type of Free Fatty acid	Structure	Molecular formula	Weight %	Structural formula	Fatty acid nature
Carboxylic Acid	16:0	$C_nH_{2n+1}COOH$	37.9	HCOOH	Saturated
Stearic acid	18:0	$C_{18}H_{36}O_2$	3.7	$C_{17}H_{35}CO_2H$	Saturated
Oleic acid	18:1	$C_{18}H_{34}O_2$	45.1	$CH_3(CH_2)_7CH=CH(CH_2)_7COOH$	Mono Saturated
Linoleic acid	18:2	$C_{18}H_{32}O_2$	10.9	$CH_3(CH_2)_4CH=CH(CH_2)CH=CH(CH_2)_7COOH$	Poly Saturated

Table.2.Physical and chemical properties of POME, Diesel and additive 1-Butanol

Properties	Test Method ASTM D 6751	POME	DIESEL	1-Butanol
Calculated cetane Index	ASTM D 613	53	48	50
Net Calorific value kJ/kg	ASTM D 4809	38928	42500	41818
Flash point (°c)	ASTM D 93	159	54	108
Density @15°c in gm/cc	ASTM D 1298	0.8826	0.830	0.8297
Kinematic Viscosity @40°c in CST	ASTM D 445	6.58	3.08	6.5

Table.3. Properties of different samples chosen for the current experimentations

Properties	Test Method ASTM D 6751	POME100	D80P20	D60P20D1B20	D50P201BC30
Calculated cetane Index	ASTM D 613	53	51.05	50.04	50.13
Net Calorific value kJ/kg	ASTM D 4809	38928	40759	40983.8	41722.6
Flash point (°c)	ASTM D 93	159	113	103.9	99.2
Density @15°c in gm/cc	ASTM D 1298	0.8826	0.8621	0.85629	0.85108
Kinematic Viscosity @40°c in CST	ASTM D 445	6.58	4.819	4.822	4.791

III. EXPERIMENTAL PROCEDURE AND TEST SET-UP

A 4-stroke, single-chambered C.I. motor (Kirloskar Engines) served as the basis for the current study. From no load to full load, performance, emissions, and combustion parameters were examined. Every fuel mix shown in different plots underwent three performance and emission parameter tests; the average results were used to create the final graphical depiction. Figure 2 shows the experimental setup that was employed for this study. To put the engine under load, an eddy current dynamo meter was connected to it. By timing the use of a known amount of fuel (10cc) from a glass burette, the fuel stream rate was

calculated. Numerous performance and emission characteristics, including BSFC and BTE, as well as HC, CO, and NO_x, were assessed [36-40]. Evaluating the dark smoke emitted by the diesel engine was the primary motivation behind smoke assessment. When evaluating the potency of smoke, perceivability served as the foundational threshold. The diesel motor smoke was estimated using a Bosch meter. It consists of an assessment unit and a testing siphon. Nearly 300cc of exhaust gas were moved by the examination siphon using a spring-operated siphon and released by the middle abdomen's pneumatic activity. In addition, the gas test was obscured by being drawn through the separating paper. A recalibrated photocell reflects meter was used to measure the spot precisely on the filter paper and determine its intensity. Bosch smoke units, which range from white to black on a scale of 10, were used to assess the spot's intensity arbitrarily. Utilizing a smoke meter, the exhaust's smoke density was determined [36-40]. The HORIBAMEXA-324 FB was employed to measure the emissions of HC and CO. The amount of pressure released during an engine cycle was measured using a piezoelectric transducer. P-theta and HRR graphs were obtained using a cathode ray oscilloscope (CRO). The gas pressure was determined by measuring the potential difference between the cylinder's inner and outer curved surfaces. The air-box method can be used to measure the air flow rate. Initially, air was drawn into the opening at the air box's entrance. Using a U-tube differential manometer, the pressure difference between the orifice and its predecessor was measured in terms of the water column. An equivalent air column is created from the water column. The volumetric efficiency can be determined using the obtained head of air. Nonetheless, a few outside variables have an impact on the engine's efficiency, emissions, and combustion characteristics. As a result, uncertainty analysis is carried out and shown in a table.

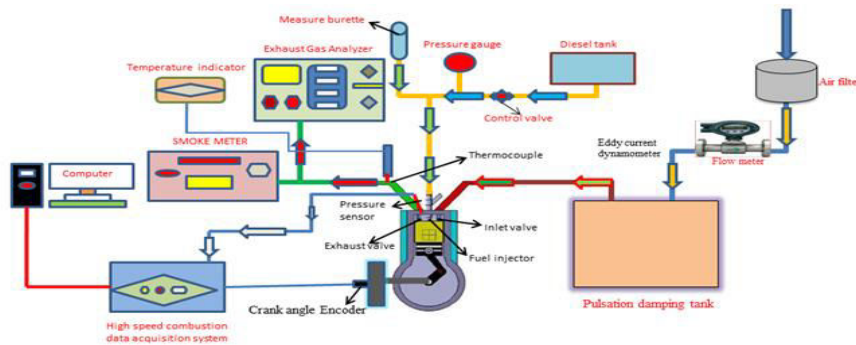


Fig.1.Schematic Outline of Experimental Test Set-up

IV. RESULTS AND DISCUSSIONS

4.1 Performance characteristics

The following sections describe various performance parameters such as brake specific fuel consumption and brake thermal efficiency at different loading conditions.

4.1.1 Brake thermal efficiency

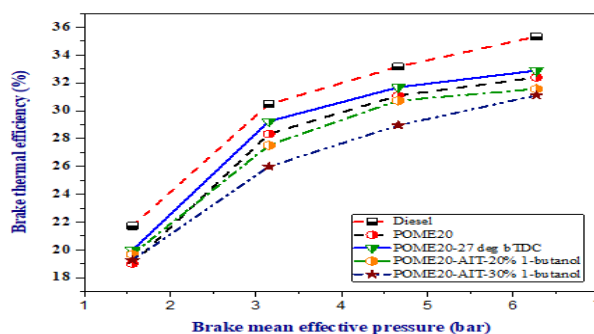


Fig.4.1 Brake Thermal Efficiency VS Brake Mean Effective Pressure



The link between brake mean effective pressure and brake thermal efficiency is shown in Fig. 4.1. The image makes it quite evident that as BMEP increases, BTE likewise increases. Low heat losses at greater loads are the cause of this. The BTEs for POME20 and pure diesel are 18.82% and 20.95%, respectively. The graph also shows that, in comparison to normal injection timing of 23⁰bTDC, BTE rose by 4.64% at advanced injection time of 27⁰ bTDC. Because of the longer physical ignition delay, BTE rose at advanced injection time, which improved fuel and air mixing and improved combustion. With advancement of injection time to 27⁰ bTDC. The blend's calorific value dropped as the concentration of 1-Butanol increased, which led to a low brake thermal efficiency. When comparing the braking thermal efficiency of POME20-20% 1-Butanol at advanced injection time to pure diesel at 1.56 pressure, 3.15 bar, 4.66 bar, and 6.27 bar, respectively, the reductions were 9.28%, 9.69%, 12.23%, and 10.58%.

4.1.2 Brake Specific Fuel Consumption

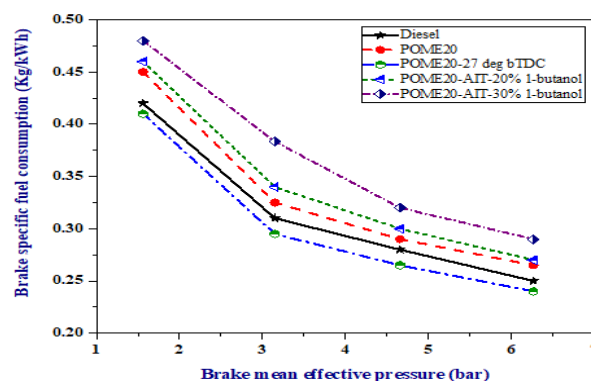


Fig 4.2 Brake specific fuel consumption Vs brake mean effective pressure

The relationship between BSFC and BMEP is depicted in the above figure. Diesel has a BSFC of 12.92% lower than POME20. Because the pine oil methyl ester was mixed with the diesel, the viscosity increased and the volatility reduced. Additionally, POME20 at advanced injection time of 27⁰bTDC is seen to consume 11.22% more fuel than diesel, while BSFC is lower than POME20 at 23⁰bTDC. An extended and stable combustion process brought about by an increase in injection timing led to a greater peak pressure shortly after the TDC. In comparison to diesel, the POME20 diesel mix with 20% more alcohol (1-butanol) added enhanced BSFC by 15.89% at advanced injection timing of 27⁰bTDC. Additionally, the addition of 30% 1-butanol to the POME20 diesel mix raised the BSFC by 22.81% at advanced injection time of 27⁰bTDC in comparison to diesel. Higher oxygen content in 1-butanol reduced the calorific value, requiring more fuel to produce the same amount of output.

4.2 Emission Characteristics

4.2.1 HC emissions

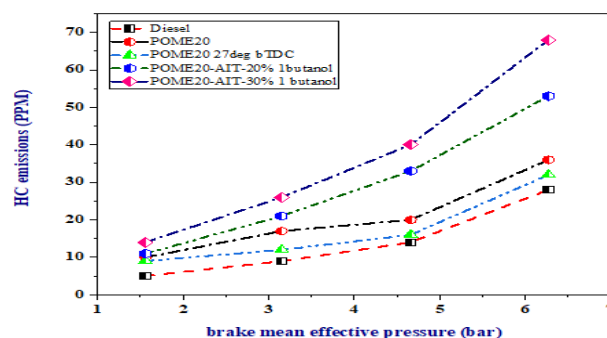


Fig 4.3 HC emissions Vs brake mean effective pressure

The relationship between HC emissions and brake mean effective pressure is depicted in the figure. The figure shows that when comparing diesel to biodiesel blend, HC emissions are higher. When comparing POME20 to diesel, the HC emissions rose by 28.57% at the usual injection timing of 23⁰b TDC. In comparison to POME20, it is noted that HC emissions decreased when injection timing progressed to 27⁰bTDC. 11.5%, 28.94%, 20.35%, and 10.86% less HC was released at 1.56 bar, 3.15 bar, 4.66 bar, and 6.27 bar, respectively. HC emissions increased when 1-butanol content increased when higher alcohol 1-butanol was added to the biodiesel blends. When comparing POME20-1B20 to POME20 at the same pressures, the HC emissions are higher by 21.38%, 46.75%, 66.27%, and 76.85%, respectively, at 1.56 bars, 3.15 bar, 4.66 bars, and 6.27 bars. For POME20-1B30, the HC fluxes are considerably boosted.

4.2.2 Carbon monoxide emissions

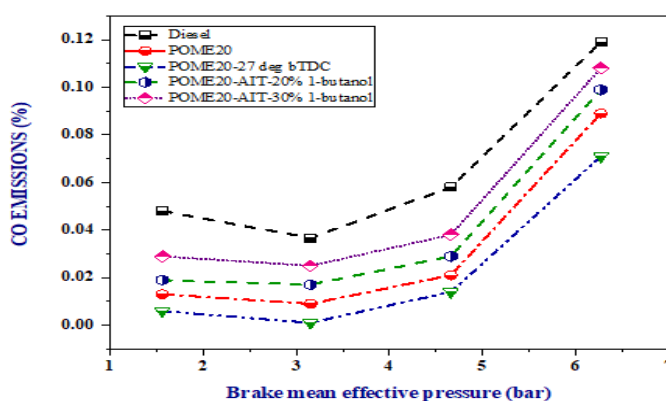


Fig 4.4 CO emissions Vs brake mean effective pressure

Biodiesel-fuelled engines generally exhibited a tendency toward full combustion due to its increased oxygen concentration and higher cetane number. In spite of this, the binary functioning of POME20 at 27⁰bTDC reduced CO by 3.68% at 100% engine load. Conversely, for all engine loads and all 1-butanol concentrations of 20% and 30%, CO emissions were lower than those of diesel fuel. Fig. illustrates that D60P20D1B20 has 2.34% fewer CO emissions than diesel fuel. The combination of the mix's intrinsic oxygen concentration and higher cetane number causes 1-Butanol and POME to be present, which expedite the combustion process and reduce CO emissions. Additionally, the cooling effects that 1-Butanol produces as a result of a higher latent heat of vaporization influences full combustion, which raises CO emissions.

4.2.3 NOx Emissions

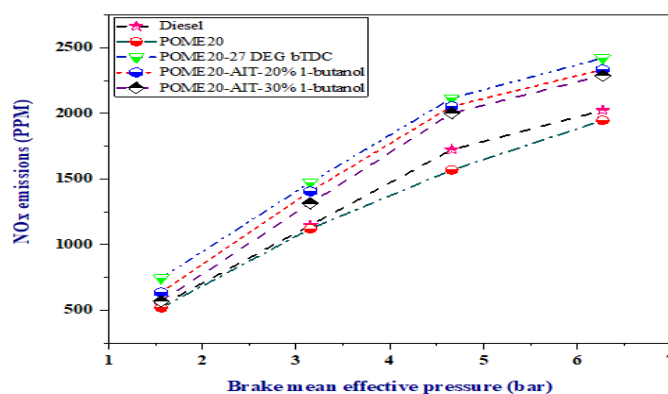


Fig 4.5 NOx emissions Vs brake mean effective pressure

The amount of NO_x in the engine exhaust compared to BMEP is shown in the above figure. Higher in-cylinder pressure causes the combustion temperature inside the combustion chamber to rise, which has the desired effect. Additionally, it has been noted that the B20's NO_x emissions are lower than those of diesel. At 6.27 bar BMEP, the NO_x emissions of the POME20 blend were 4.12% lower than those of the diesel. POME20 is found to emit more NO_x at advanced injection timings of 27⁰bTDC than it does at regular injection timings. In comparison to POME20 at conventional injection time, the NO_x emission of POME20 with advanced injection timing is 25% greater, at 27⁰bTDC. For POME20-1B20, the NO_x emissions are 635 ppm, 1405 ppm, 2053 ppm, and 2334 ppm at 1.56, 3.15, 4.66, and 6.27 bars, respectively. As the concentration of stronger alcohols increased, the NO_x emissions decreased. In comparison to POME20, the NO_x emissions of POME20-1B20 dropped by 4.56%, while those of POME20-1B30 declined by 3.67%. The blend's increased latent heat of vaporization of alcohol, which has a cooling impact during combustion, is what caused the reduction in NO_x emissions. Low combustion temperatures are a result of the latent heat of vaporization, which is a major factor in the combustion process.

4.2.4 Smoke opacity

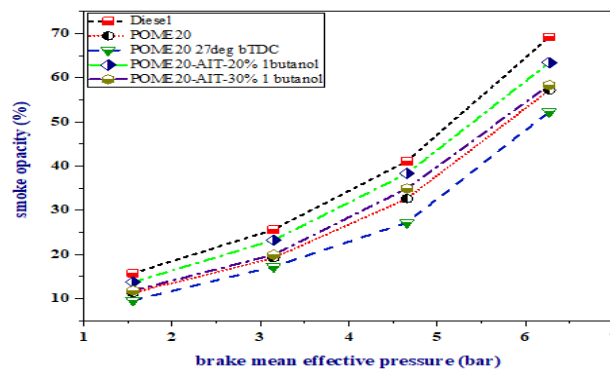
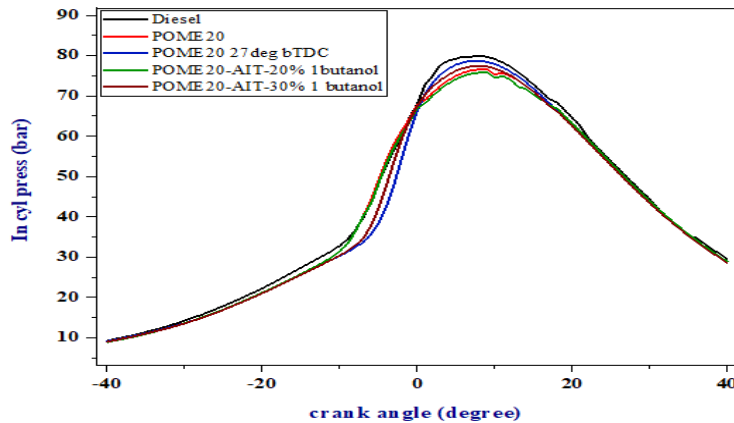


Fig 4.6 Smoke opacity Vs brake means effective pressure

The relationship between smoke opacity and break mean effective pressure is shown in the above figure. It can be seen that smoke opacity decreased for pine oil blends compared to diesel. The smoke opacity decreased by 22%, 17%, 23%, and 13.35% at 1.56 bar, 3.15 bar, 4.66 bar, and 6.27 bar compared to diesel. The graph clearly shows that advancing injection timing of POME20 to 27⁰bTDC decreased smoke opacity. In comparison to POME20, the smoke opacity dropped by 22.37% at the recommended injection timing. At peak pressure, the smoke opacity rose by 41.59% in comparison to POME20. This is because there is more latent heat evaporation, which lowers the temperature inside the cylinder and encourages the creation of smoke. As the concentration of 1-butanol increased, the smoke's opacity reduced.

4.3 Combustion Characteristics

4.3.1 In-cylinder pressure



4.7 In-cylinder pressure Vs crank angle

Figure displays various in-cylinder weight variations with different wrench points. The in-barrel weight 40^0 bTDC in compression stroke to 40^0 after TDC is depicted in the figure. Diesel has a peak cylinder pressure of 81 bars, but the POME20-1B20 has a peak cylinder pressure of 74 bars. The reduction is caused by the blend's higher latent heat of alcohol vaporization and decreased calorific value, which work together to lessen heat generation inside the combustion chamber. It is also observed that the cylinder pressure decreases as the blend's alcohol content rises. In comparison to POME20-1B20, the in-cylinder pressure was lower for POME20-1B30.

4.3.2 Net Heat Release Rate

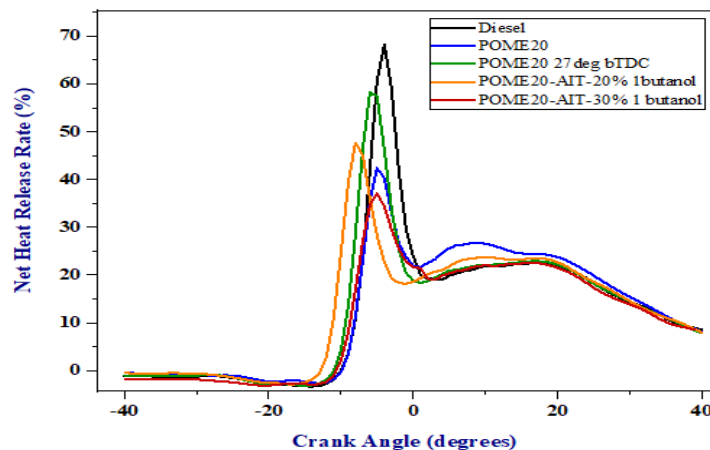


Fig 4.8 Net heat release rate Vs crank angle

The relationship between crank angle change of -40^0 to $+40^0$ and net heat release rate is seen in the above image. Diesel has a higher net heat release rate than all other fuels combined. Diesel has a 69% net heat release rate. In comparison to diesel, the net heat release rate dropped for blends containing pine oil. There was a 37% decline in value. The net heat release rate remains lower than diesel, having increased by 27.67% when compared to POME20 at 23^0 bTDC. As injection timing advances at full load, the ignition delay time lengthens, leading to increasing pressure and heat release rate from efficient combustion. Diesel, POME20 at 23^0 bTDC, and POME20 at 27^0 bTDC have net heat release rates of 68%, 42%, and 58%, respectively. Net heat release rate was reduced by adding more alcohol (1-butanol) to the POME

blends at advanced injection timing. POME20-1B20 and POME20-1B30 have net heat release rates of 59% and 48%, respectively.. Because of the mixes' lower calorific value, the addition of more alcohol led to a decreased heat release rate when compared to pure biodiesel.

4.3.3 Mean Gas Temperature

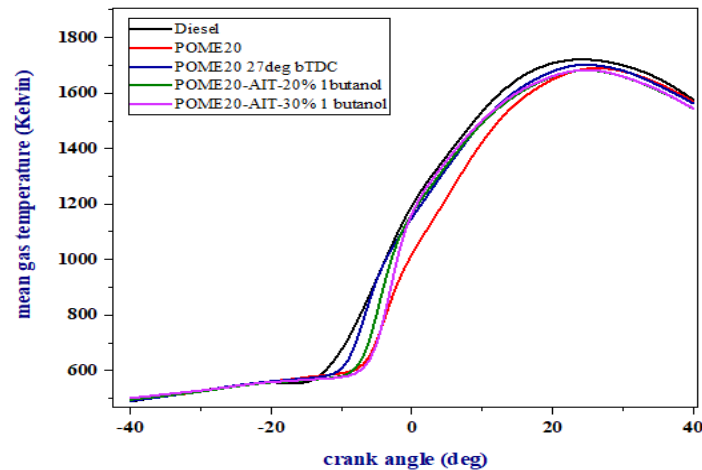


Fig 4.9 mean gas temperature Vs crank angle

The link between crank angle and mean gas temperature is seen in the above figure. Diesel has been found to have a higher mean gas temperature than all other blends, regardless of injection timings. The diesel has a mean gas temperature of 1510k at the same angle, whereas the POME20's mean gas temperature at 23⁰bTDC is 1300k at 10⁰ crank angle. The decreased calorific value of pine oil biodiesel and the poor spray and flame characteristics caused by excessive viscosity are the two main causes of the decrease in mean temperature for blends including pine oil. The blend's mean gas temperature rose when the injection timing for the POME20 was advanced to 27⁰bTDC as opposed to 23⁰bTDC. The temperature increase is caused by Improvements in injection time at full load lead to an increase in the ignition delay period, which raises pressure and accelerates heat release because of efficient combustion. At 27⁰bTDC, the diesel, POME20, and POME20 have mean gas temperatures of 1514 k, 1300 k, and 1442 k, respectively, at a 10⁰ crank angle.

The mean gas temperature decreased for all samples when more alcohol 1-butanol was added to the pine oil biodiesel mixes. POME20-1B20's mean gas temperature is 1342 k. At 23⁰bTDC, the temperature is higher than POME20, but at 27⁰bTDC, it is lower than POME20. Lower cethane numbers cause a longer ignition delay, which delays the beginning of combustion and causes a drop in temperature. For the samples of higher alcohol blends, the mean gas temperatures are nearly equal. The temperature differences between POME20-1B20 and POME20-1B30 are not very great.

V. CONCLUSION

In this study, the effects of various concentrations of higher alcohol (1-butanol) blends at advanced injection with palm oil methyl ester (POME) on performance, emissions, and combustion characteristics were examined and compared with clean biodiesel and baseline diesel fuel in a diesel engine. The experiment's findings lead to the following deductions:

- When compared to pure POME at advanced injection timing, the addition of more alcohol to the POME fuel at advanced injection timing reduced the fuel's brake thermal efficiency.
- When comparing the BTE of the blended fuel to that of diesel, it was low. When comparing all blended fuels to diesel at all load ranges, the BSFC was high; however, BTE rose with increasing the injection timing for the same blend. As the injection timing advanced, the BSFC fell.
- The performance of POME20 was enhanced by the increase in injection timing, although the mix produced more NO_x emissions than any other. With POME20's improved injection timing, other emission characteristics like HC emissions and smoke opacity also decreased. When diesel engines run on POME-

alcohol blends instead of POME20 fuel, the NO_x emissions are reduced. This reduction is noticeable across all blend fractions with increased alcohol content.

- Because biodiesel is oxygenated, smoke opacity for POME20 fuel was found to be significantly lower than that of diesel fuel. In contrast to POME20 gasoline, greater alcohol/POME blends produce more smoke. The higher alcohol content in the mixes may have poor auto ignition and evaporation qualities, which increase the amount of flame quenching zones inside the combustion chamber and cause incomplete combustion.
- Compared to other biodiesel blends, POME20-AIT produces a higher peak pressure due to its 30% alcohol content. This is due to the fact that adding alcohol raises the mix's calorific value and oxygen content, which raises the peak pressure.
- Because alcohol burns similarly to biodiesel and has a high cetane number and oxygen content. Because of this, the POME20-AIT 1B30 blend batter has a larger net heat release rate than the other blends.

REFERENCES

- [1] K.Madhu babu, N.Sivanagaraju, R.Nagendra babu, "An experimental investigation on characteristics of a diesel engine with pine oil blends and by adding decanol as an additive." *Materials Today: Proceedings*, <https://doi.org/10.1016/j.matpr.2023.04.401>.
- [2] S.Veerendra Kumar, V.Mohan Manoj, and K.Madhu Babu, "Effect of operating parameters and antioxidant additives with Palm-biodiesels to improve the performance and diminishing the emissions in a compression ignition engine." *Solid State Technology* 63.6 (2020): 22430-22446.
- [3] N. Sivarama Krishna,, and R. Vijay Krishna, "Investigation of Performance and Emission Characteristics of Jackfruit Seed Methyl Ester Blends with Additive and Advanced Injection Timing." *Solid State Technology* 64.1 (2021): 4050-4062.
- [4] K.Nanthagopal, B.Ashok, A.Tamilarasu, A.Johny, A.Mohan, "Influence on the effect of zinc oxide and titanium dioxide nanoparticles as an additive with Calophyllum inophyllum methyl ester in a CI engine." *Energy Conversion and Management* 146:8-19.
- [5] Xue, Jinlin. "Combustion characteristics, engine performances and emissions of waste edible oil biodiesel in diesel engine." *Renewable and Sustainable Energy Reviews* 23 (2013): 350-365, <https://doi.org/10.1016/j.rser.2013.02.039>.
- [6] Subbaiah, G. Venkata, et al. "Rice bran oil biodiesel as an additive in diesel-ethanol blends for diesel engines." *International journal of research and reviews in Applied sciences* 3.3 (2010): 334-342.
- [7] Devarajan, Yuvarajan, et al. "Experimental analysis of Sterculia foetida biodiesel and butanol blends as a renewable and eco-friendly fuel." *Industrial Crops and Products* 178 (2022): 114612.
- [8] Devarajan, Yuvarajan, et al., "Performance, combustion and emission analysis of mustard oil biodiesel and octanol blends in diesel engine." *Heat and Mass Transfer* 54 (2018): 1803-1811.
- [9] Kumar, Naveen, and Harveer Singh Pali. "Effects of n-butanol blending with Jatropha methyl esters on compression ignition engine." *Arabian Journal for Science and Engineering* 41.11 (2016): 4327-4336.
- [10] A.K. Agarwal, and I.M. Das, "Bio-diesel development and characterization for use as a fuel in compression ignition engines." *Journal of engineering for Gas Turbine and Power Transactions, ASME* (2001) 123: 440 – 447.
- [11] Avinash Kumar Agarwal, Atul Dhar, Karanja Oil Utilization in DI Engine by Preheating, "Experimental Investigations of Engine Performance, Emissions and Combustion Characteristics." Part I, Proc. IMechE Part D: J.Automobile Engineering, June (2009) Vol.224, pp.73 – 84.
- [12] S. Karthikeyana, A. Elangob, A. Prathimac, "Performance and Emission Study on Zinc Oxide Particles Addition with Promolion Steering Wax Biodiesel of Engine." *Journal of Science and Industrial Research* 73 (2014).
- [13] G.V. Churchil, C. Ananda Srinivasan, "Performance and emission analysis of Indian Jujube Seed oil as bio-diesel." *International Journal of Engineering and Technology*, Vol.6 Issue 02, February – 2017.
- [14] R. Satish Kumar, K. Suresh Kumar, "Manilkara Zapota (L.) Seed Oil: A new third generation biodiesel resource." *Waste Biomass Valor* (2016), DOI 10.1007/s12649-016-9491-7.
- [15] Sanjid Ahmed, Masjuki Hj Hassan, Md. Abul Kalam, S.M. Ashrafur Rahman, Md. Joynul Abedin, Ali Shahir, "An Experimental Investigation of biodiesel production, Characterization, engine performance and noise of Brassica juncea methyl ester and its blends." *Journal of cleaner production* (2014) 1–8.
- [16] Senthil Ramalingam, Silambarasan Rajendran, "Effect of operating parameters and antioxidant additives with biodiesels to improve the performance and reducing the emissions in a compression ignition engine." *Renewable and Sustainable Energy Reviews* 81 (2018) 775–788.
- [17] K. Velmurugan, A.P. Sathiyagnanam, "Impact of antioxidants on NO_x emissions from a mango seed biodiesel powered DI diesel engine." *Alex. Eng. J.* (2015).

- [18] K. Nanthagopal, B. Ashok, "Study on decanol and Calophyllum Inophyllum biodiesel as ternary blends in CI engine." *Fuel* 239 (2019) 862–873.
- [19] S. Senthur Prabu, M.A. Asokan, "Effect of additives on performance, combustion and emission behaviour of preheated palm oil/diesel blends in DI diesel engine." *Renew. Energy* 122 (2018) 196–205.
- [20] S. Imtenan, H.H. Masjuki, M. Varman, "Impact of oxygenated additives to palm and jatropha biodiesel blends in the context of performance and emissions characteristics of a light-duty diesel engine." *Energ. Conver. Manage.* 83 (2014) 149–158.
- [21] M. Pugazhivadivu, "Studies on the effect of ethanol addition to biodiesel, Performance and emissions of a diesel engine." *Indian Journal of Science and Technology*, Vol.2 No. 11 (Nov. 2009), ISSN: 0974- 6846.
- [22] S. Puhan, N. Vedaraman, B.V.B. Ram, G. Sankarnarayanan, K.Jeychandran, "Mahua oil (Madhuca Indica seed oil) methyl esters biodiesel-preparation and emission characteristics." *Biomass Bioenergy* [Internet]. Elsevier BV 28 (1) (2005) 87–93. Available from: <http://dx.doi.org/10.1016/j.biombioe.2004.06.002>.
- [23] V. Vibhanshu, N. Kumar, A. Singh, C. Mishra, "An experimental investigation on performance and emission studies of a single cylinder diesel engine fuelled with blends of diesel and mahua oil methyl ester." *SAE Technical Paper Series* [Internet]. SAE International 2013 Apr 8. Available from: <http://dx.doi.org/10.4271/2013-01-104>.
- [24] D. Sonar, S.L. Soni, D. Sharma, A. Srivastava, R. Goyal, "Performance and emission characteristics of a diesel engine with varying injection pressure and fuelled with raw mahua oil (preheated and blends) and mahua oil methyl ester." *Clean Technol. Environ. Policy* [Internet] 17 (6) (2014) 1499–1511, <http://dx.doi.org/10.1007/s10098-014-0874-9>, Springer Nature.
- [25] Performance and emission analysis of ci engine on mahua oilbiodiesel. *Int. J. Curr. Eng. Technol.* [Internet]. Inpressco, 2011 Jan 1. Available from: <http://dx.doi.org/10.14741/ijcet/22774106/spl.5.6.2016.3>.
- [26] D. Yuvarajan, J. Ravikumar, M.D. Babu, "Simultaneous optimization of smoke and NOx emissions in a stationary diesel engine fuelled with diesel–oxygenate blends using the grey relational analysis in the Taguchi method." *Anal Methods* [Internet]. Royal Society of Chemistry (RSC) 8 (32) (2016) 6222–6230. Available from: <http://dx.doi.org/10.1039/c6ay01696k>.
- [27] P.C. Jena, H. Raheman, G.V. Prasanna Kumar, R. Machavaram, "Biodiesel production from mixture of mahua and simarouba oils with high free fatty acids." *Biomass Bioenergy* [Internet]. 34 (8) (2010) 1108–1116, <http://dx.doi.org/10.1016/j.biombioe.2010.02.019>, Elsevier BV.
- [28] D.K. Bora, M. Polly, V. Sanduja, "Performance evaluation and emission characteristics of a diesel engine using Mahua Oil Methyl Ester (MOME)." *SAE Technical Paper Series* [Internet], SAE International, 2004, 10.4271/2004-28-0034.
- [29] V. Vibhanshu, A. Karnwal, A. Deep, N. Kumar, "Performance, emission and combustion, analysis of diesel engine fuelled with blends of Mahua oil methyl ester and diesel." *SAE Technical Paper Series* [Internet], SAE International, 2014.
- [30] R.L. McCormick, J.D. Ross, M.S. Graboski, "Effect of several oxygenates on regulated emissions from heavy-duty diesel engines." *Environ. Sci. Technol.* 31 (1997) 1144–1150.
- [31] M. Ishida, S. Yamamoto, H. Ueki, D. Sakaguchi, "Remarkable improvement of NOx–PM trade-off in a diesel engine by means of bioethanol and EGR." *Energy* 35 (2010) 4572–4581.
- [32] A. Deep, N. Kumar, A. Karnwal, D. Gupta, V. Vibhanshu, A. Sharma, et al, "Assessment of the performance and emission characteristics of 1-octanol/ diesel fuel blends in a water cooled compression ignition engine." *SAE Tech. Paper* 01 (2014) 2830.
- [33] T. Zhang, K. Munch, I. Denbratt, "An experimental study on the use of butanol or octanol blends in a heavy duty diesel engine." *SAE Tech. Paper* 24 (2015) 2491.
- [34] B. Rajesh Kumar, S. Saravanan, D. Rana, V. Anish, A. Nagendran, "Effect of a sustainable biofuel – n-octanol – on the combustion, performance and emissions of a DI diesel engine under naturally aspirated and exhaust gas recirculation (EGR) modes." *Energy Convers. Manage.* 118 (2016) 275–286.
- [35] M. Venkata Ramanan, D. Yuvarajan, "Emission analysis on the influence of magnetite nanofluid on methyl ester in diesel engine, Atmospheric Pollution Research [Internet]." Elsevier BV 7 (3) (2016) 477–481. Available from: <http://dx.doi.org/10.1016/j.apr.2015.12.001>.
- [36] Y. Devarajan, B.K. Nagappan, D.B. Munuswamy, "Performance and emissions analysis on diesel engine fuelled with cashew nut shell biodiesel and pentanol blends." *Korean Journal of Chemical Engineering* [Internet]. Springer Nature 34 (4) (2017) 1021–1026. Available from: <http://dx.doi.org/10.1007/s11814-016-0364-3>.
- [37] S. Dhingra, G. Bhushan, K.K. Dubey, "Performance and emission parameters optimization of mahua (Madhuca indica) based biodiesel in direct injection diesel engine using response surface methodology." *J. Renew. And Sustain. Energy* [Internet]. 5 (6) (2013) 063117, <http://dx.doi.org/10.1063/1.4840155>. AIP Publishing.



[38] Y. Devarajan, D. babu Munuswamy, B. Nagappan, “Emissions analysis on diesel engine fuelled with cashew nut shell biodiesel and pentanol blends.” Environ. Sci. Pollut. Res. (2017). Available at: <http://dx.doi.org/10.1007/s11356-017-8915-7>.

[39] M. Sivakumar, N. Shanmugasundaram, R. Rameshkumar, M. Syed Thasthagir, “Effects of pongamia methyl esters and its blends on a diesel engine performance.” combustion, and emission characteristics, Environmental Progress & Sustainable Energy [Internet]. Wiley-Blackwell 2016 Oct. Available from: <http://dx.doi.org/10.1002/ep.12492>.

[40] D. Yuvarajan, Ramanan M. Venkata, “Investigation on effect of magnetite nanofluid on performance and emission patterns of methyl esters of bio diesel.” J. Environ. Eng. Landscape Manage. 24 (2016) 90.



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