International Journal of Environmental and Ecology Research
www.environmentaljournal.in
Online ISSN: 2664-7117; Print ISSN: 2664-7109; Impact Factor: RJIF 5.42
Received: 26-01-2021; Accepted: 11-02-2021; Published: 04-03-2021
Volume 3; Issue 1; 2021; Page No. 15-18

Performance and emission stratefies of calophyllum inophyllum biodiesel using zinc oxide nanoparticles as fuel additives

Kandula Lakshmi Kamala[1], V Ravi Kumar[2]
[1] M. Tech Student, Department of Mechanical Engineering, Akula, Sreeramulu College of Engineering, Tanuku, West Godavari District, Andhra Pradesh, India
[2] Assistant Professor, Department of Mechanical Engineering, Akula, Sreeramulu College of Engineering, Tanuku, West Godavari District, Andhra Pradesh, India

Abstract
Now a days the world is confronting with twin crises such as energy demand and pollution. The economic growth of any county is related with energy demand. IC Engines are the major energy consumers to eradicate the problem alternative fuels are one major source to replace diesel fuel partially or fully. The availability of conservative fuels decreased continuously, these reasons makes to find the alternative fuels especially biofuels. The use of biodiesel considerably reduced emission and increase the performance of the engine. Now a days researchers have reported the possibility for the production of biodiesel from non edible oil jatropha curcus, pongamia pinnata etc. In the present years, population of vehicles increased enormously which increases the demand of fossil fuel, There is a best source of raw material that is calophyllum inophyllum oil for biodiesel production. In present study calophyllum inophyllum is used as fuel in C.I engine. Blends such as CIME10, CIME20, CIME30, CIME40 are taken for the experimentation. The optimized blend is identified as CIME20 while compared the test results with the baseline readings of diesel fuel. The optimized blend is further tested with Zinc Oxide nanoparticles as fuel additive with various concentrations of 25ppm, 50ppm and 75ppm. Brake thermal efficiency is increased by 3.48 % and Brake specific fuel consumption is reduced by 7.12% and emission of CO and Unburnt Hydro carbons are reduced where as NOX results are moderate.

Keywords: biodiesel, calophyllum inophyllum, efficiency, emissions, nanoparticles

Introduction

The environmental degradation and the dearth of petroleum based fuels make it necessary for the search of new possible sources of renewable energy. In addition to that the vehicles that use petroleum based fuels have to meet the progressively stringent emission norms, where the conventional fuels are finding it difficult to meet those standards. Use of various fossil fuels such as petroleum products and coal has increased the CO2 level in atmosphere from the pre-industrial era of 280 ppm to the present state of 350 ppm (Kessel 2000) [1]. CO2 level is still climbing up as a function of conventional fuel usage leading to greenhouse effect, acid rains, smog and worldwide climate change (Cao 2003) [2].

The Fifth Assessment Report released by the intergovernmental panel on climate change (IPCC) (2 November 2014) states that the world will have to completely phase out fossil fuels in electricity generation by the end of this century and reduce their use to 20% by 2050 to avoid disastrous consequences of climate change. It was also said that if nations fail to bring emissions of greenhouse gases to near zero by the year 2100, climate change would leave severe, wide spread and irreversible impacts. A reduction in emission is also expected by 40 to 70% globally between 2010 to 2050, falling to zero or below zero by 2100, to keep the rise of global temperature below 2oC from 1800 level. This intrinsic issue has made researchers to search for an alternative and eco-friendly fuel that will reduce the import of crude oil for oil importing nations like India, which would improve the economy of the country and significantly reduce the emissions.

Biodiesel Preparation

Calophyllum Inophyllum plant is available in Africa, Asia, and Pacific regions (Dweck & Meadowsy 2002) [3]. It is a member of the mangosteen family. It is also named as Alexandrian Laurel, Tamanu, Pannay Tree, Sweet Scented Calophyllum, Punnai, etc. In India, these trees are found mostly in coastal areas, which are planted to prevent soil erosion. They grow around 2-3 m in hight with thick rough trunk having cracked barks. The leaves are strong and elliptical in shape and flowers are arranged in auxiliary cymes which emits sweet lime-like fragrance. They flower twice a year and yield numerous spherical drupes that are arranged in clusters. Each seed is around 50 mm in diameter having smooth epidermis layer followed by hard cover which encloses a rather pale yellow kernel of around 25 mm in diameter weighing approximately 7g. The seeds are collected and sun dried to separate the kernels by breaking the outer shell. They are then dried and crushed to extract oil by allowing it to pass through a screw press. The extracted oil is then filtered and the seed cake, which is rich in protein is used as cattle and poultry feed.

The extracted tamanu oil had an acid value of 48 mg KOH/g, which is equivalent to 24 % free fatty acid (FFA) content. High FFA content demands two stage esterification processes with acid and base catalyst. The extracted fuel is converted into biodiesel through transesterification process. The properties are tested as per the ASTM standards and tabulated in table 1. The tested fuel is blended with diesel in four proportions such as 10%, 20%, 30% and 40% named as CIME10, CIME20, CIME30 and CIME40.

Table 1: Properties of Tested fuels

Sl. No	Property	Calophyllum inophyllum Bio-diesel	Diesel
1	Calorific Value kJ/kg	38500	42,500
2	Flash Point(°c)	146	93
3	Fire Point(°c)	152	62-106
4	Cloud Point(°c)	7.5	-12
5	Pour Point(°c)	-	-20
6	Acid Value mg/KOH	-	0.36 mg/KOH
7	Density kg/m^3	878	849
8	Viscocity mm^2/s	4.18	2.6
9	Cetane Number	51.2	54.6

Experimentation

The VCR engine test rig is a computer based analysis engine by using different sensors and thermocouples. The sensors are used in the present test rig that are used to find the speed, torque, fuel consumption etc., k-type thermocouples are used in the test rig to measure the temperature at various points.

Engine specifications: 4 stroke computerized variable compression ratio multi fuel direct injection water cooled engine,Make: TECH-ED, Basic engine: Kirloskar, Rated power: 5 HP (DIESEL), Rated power: Up to 3 HP (PETROL), Bore diameter: 80mm, Stroke length: 110mm, Connecting rod length: 234mm, Swept volume: 551cc, Compression ratio: 5:1 to 20:1, Rated speed: 1500 rpm

Initially the baseline test was conducted using diesel at various loads from no load to full load condition in five intervals(0%,25%,50%,75%,100%). the performance and combustion are observed using engine test software which are loaded in the computer through interface The emission analysis is carried out Airval automation emission analyser and AVL smoke meter The six gas smoke analyser gives the percentage of CO (carbon monoxide), NOx (nitrogen oxide), SOx (sulphur oxide), oxygen (O2), carbon dioxide (CO2), HC(hydro carbons) and smoke meter will gives the amount of smoke coming from the engine.

Fig 1: Photographic view of experimental setup

Results and Discussion

Performance and Emission Analysis of Calophyllum Inophyllum Biodiesel blends

Brake thermal Efficiency (BTHE)

The performance analysis mainly depends on the BTHE, BP and BSFC. From this diagram we get how the BTHE is varies for different fuel combination with respective to the BP is to be formed at higher BP condition which having higher BTHE that will be considered as efficient fuel.

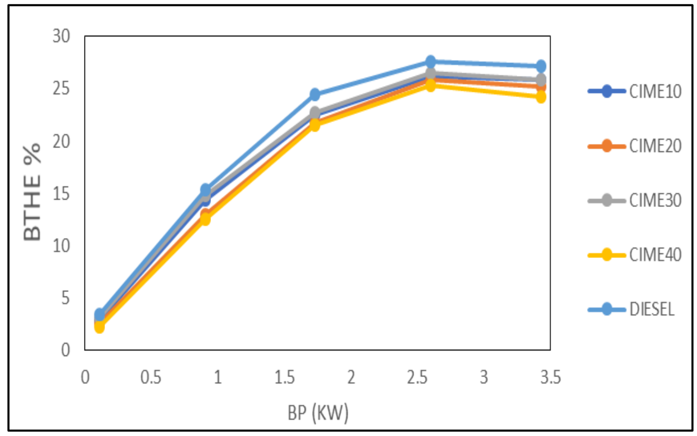

Fig 2: Variation of BTHE of CIME blends with Brake power

BTHE for various blends were observed. The plot of BTHE against brake power is shown in Fig.2 The comparison of BTHE for CIME10, CIME20, CIME30, CIME40 are shown in the graph. It is found that CIME20 gives better BTHE at rated loads compared to standard diesel. This may be attributed to extra oxygen content of biodiesel blends which improves the combustion process tends to increase in BTE of the engine (Hwai 2014) [5].

Brake Specific Fuel Consumption (BSFC)

Specific fuel consumption consideration is mainly for economic purpose at higher loads condition at which fuel will give low SFC value that is used as economic fuel.

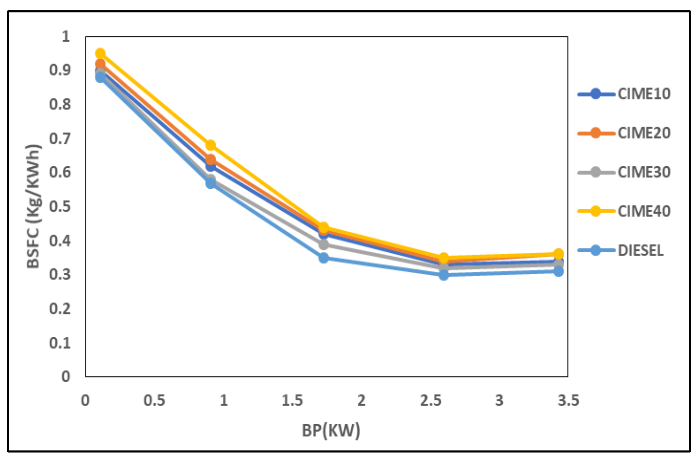

Fig 3: Variation of BSFC of CIME blends with Brake power

By observing the figure 3 BSFC v/s LOAD the BSFC is decreasing linearly for all fuel combinations w.r.t to the load. The indication of SFC is for economy. By comparing all fuel combinations the CIME20 having the lowest BSFC and all CIME combinations having less fuel consumption.

Carbon Monoxide Emissions

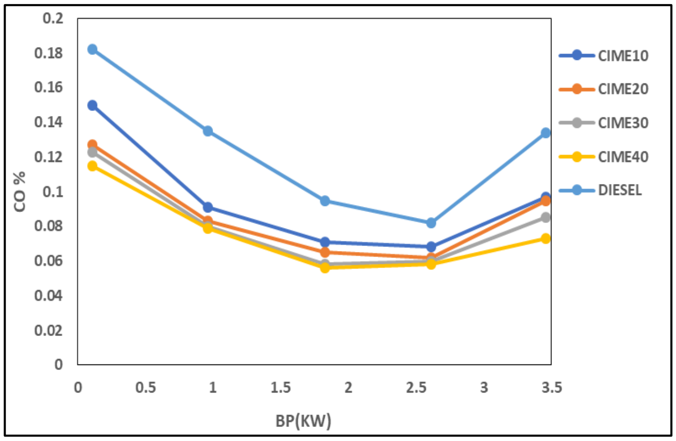

Fig 4: Variation of CO emissions of CIME blends with Brake power

CO emissions from the engine occur due to partial oxidation of the fuel mixture. The rate of CO formation is a function of unburned fuel and mixture temperature during combustion. The variation of CO emissions against brake power is shown in Fig.4 It is observed that CIME20 has low emission of CO, at part load as compared with neat diesel. The CO emission is increased for higher loads. Main reason behind the CO emission is incomplete combustion**,** Due to the faulty dry air filter, Mixture of air-fuel ratio. Due to better combustion the Carbon monoxide emissions were decreased for all the CIME blends and is more for CIME20. Based on the performance and emission results the CIME20 blend produces best performance and emission results so further investigation will be carried out with nano particles used as fuel additives.

Performance & Emission Analysis of Cime20 with Zinc Oxide Nanoparticles as fuel Additives

It is observed that CIME20 has good performance characteristics compared to the other blends and diesel. To improve the performance characteristics of CIME20, fuel additives such as Zinc Oxide is added to the CIME20 in three different concentrations (25ppm, 50ppm and 75 ppm).

Brake Thermal efficiency

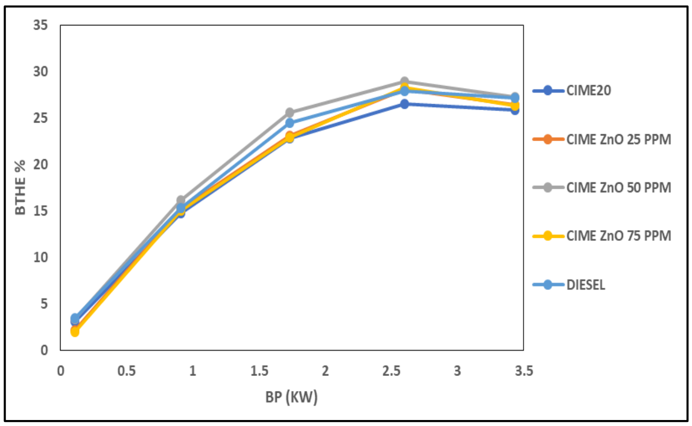

Fig 5: Variation of BTHE of CIME20 ZNO blends with Brake power

It is observed that graph is drawn brake power against brake thermal efficiency. From the figure 5 CIME 20 ZNO 50 has high thermal efficiency of 28.95 % compared to the other blends compared to diesel. This may be attributed to extra oxygen content of biodiesel blends which improves the combustion process tending to increase in BTHE of the engine. BTHE is increased by 3.48 % compared to standard base line results of diesel fuel.

Brake Specific Consumption

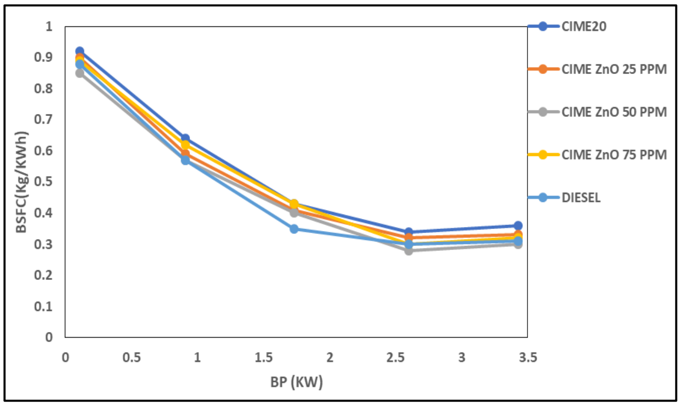

Fig 6: Variation of BSFC of CIME20 ZNO blends with Brake power

Specific fuel consumption consideration is mainly for economic purpose at higher loads condition at which fuel will give low SFC value that is used as economic fuel. By observing BSFC v/s BP the BSFC is decreasing linearly for all fuel combinations w.r.t to the load. The indication of SFC is for economy. By comparing all fuel combinations the CIME20 ZNO 50 having the lowest BSFC and is reduced by 7.14% compared to diesel fuel at rated load.

Carbon Monoxide Emissions

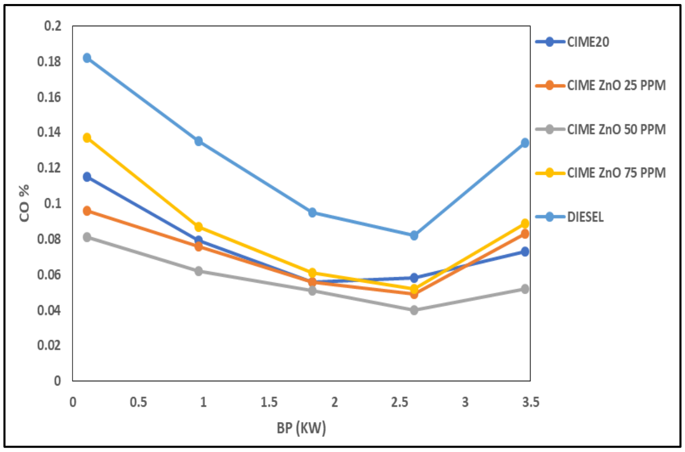

Fig 7: Variation of CO emissions of CIME20 ZNO blends with Brake power

CO emissions from the engine occur due to partial oxidation of the fuel mixture. The rate of CO formation is a function of unburned fuel and mixture temperature during combustion. The variation of CO emissions against brake power is shown in Fig.7 It is observed that CIME 20 ZNO 50 has low emission of CO, at part load as compared with neat diesel. The CO emission is increased for higher loads. The CO emissions were reduced by 65% compared to diesel fuel.

Conclusions

The main objective of the present study was to use the non-edible calophyllum inophyllum oil as biodiesel in CI engine. To reduce the viscosity of neat calophyllum inophyllum, transesterification was done to bring it close to that of conventional diesel. In order to obtain a basis for comparison, various blends are used such as (B10, B20, B30, B40) from this blends B20 shows best results compared to the diesel. To improve the performance characteristics Zinc Oxide Nanoparticles additive added in the B20 in the concentration of 25 ppm, 50 ppm and 75 ppm.

- CIME20 gives the good performance and emission results in single cylinder operation
- In CIME20 has low emission parameters except NOx and smoke emission compared to diesel engine operation.
- The performance of CIME20 is further increased by adding Zinc Oxide Nanoparticles additive.
- Finally we conclude that by observing performance, combustion and emission analysis the combination of CIME 20 ZNO 50 is acts like a diesel fuel with small deviations. At full load condition the CIME 20 ZNO 50 will produce maximum BTHE, low BSFC and Emissions like HC and CO reduced. So, this combination is recommendable for the stationary engine.

References

1. Kessel DG. Global warming – facts, assessment, counter measures‟, Journal of Petroleum Science and Engineering. 2000; 12:157-168.
2. Cao X. Climate change and energy development; implications for developing countries‟, Resource Policy. 2003; 29:61-67.
3. Dweck AC, Meadowsy T. Tamanu Calophyllum inophyllum) – the African, Asian, Polynesian and Pacific Panacea‟, International Journal of Cosmetic Science. 2002; 24:341-348.
4. Intergovernmental Panel on Climate Change (IPCC) 2014, Fifth Assessment Report (AR5) - Climate Change 2014. Available from, 2014.
5. Hwai CO, Masjuki HH, Mahlia TMI, Silitonga AS, Chong WT, Leong KY *et al*. Optimization of biodiesel production and engine performance from high free fatty acid Calophyllum inophyllum oil in CI diesel engine‟, Energy Conversion and Management. 2014; 81:30-40.
6. Nithin Samuel, Muhammed Shefeek K. “Performance and Emission Characteristics of a C.I Engine with Cerium Oxide Nanoparticles as Additive to Diesel”, International Journal of Science and Research. 2015; 4(7):673- 676.
7. Abbas Alli Taghipoor Bafghi, Hosein Bakhoda, Fateme Khodaei Chegeni. “Effects of Cerium Oxide Nanoparticle Addition in Diesel and Diesel-Biodiesel Blends on the Performance Characteristics of a CI Engine”, International Journal of Mechanical and Mechatronics Engineering. 2015; 9(8):1507-1512.
8. Sam Sukumar R, Muralidhara Rao M, Gopala Krishna A. “Performance, Combustion and Emission Strategies of Hazantus Algae Methyl Ester Blends Using Cerium Oxide Nanoparticles As Additive”, International Journal of Advanced Science and Technology. 2020; 29(4):65-73.
9. R Sam Sukumar, Muralidhara Rao M, Gopala Krishna A. “Performance and Emission Strategies of Biodiesel with Various Engine Operating Conditions” International Journal of Ecology and Environmental Sciences. 2020; 2(4):736-742.