Effect of Cerium Oxide Nano Additives on the Performance, Combustion and Emission Parameters of a Hazantus (ALGAE) Bio Diesel in a 4-Stroke DI CI Engine

Narkedamilli Pavan Kumar, K. Venkateswararao

Abstract--- ***In the Alternate fuel area Bio Diesel will plays a major role. Most of the bio diesel is derived from seed-based source like Pongamia and Jatropha in Bharat. The problem associated with the seed-based sources are yield time, yield of crop. An and average a pongamia tree can produce seeds up to 9 to 90 per tree per year. The alternate energy is waiting for a source having less yield time and high capacity of yield. Algae is a moss family micro plant which is grown within one week having high lipid content. The oil yield from algae is about 20 to 90% achieved by various oil extraction process like solvent extraction method, soxhlet extraction, mechanical pressing, pyrolysis etc…. To reduce the viscosity, separate the glycerin from the neat oil Transesterification is used. In the present research the Hazantus (Algae Bio Diesel) is blended with the fossil based diesel fuel at various proportions i.e. 10% (ALME 10), 20% (ALME 20), 30% (ALME 30) tested in a Computerized water cooled DI Engine along with pure Hazantus (Algae Bio Diesel) (ALME) and Fossil based Diesel Fuel to identify the best blend by performance, Combustion parameters. The blend ALME 10 is the best proportion in terms of Performance and Combustion. For this blend the Cerium Oxide Nano Particles are added at a proportion of 25 mg (ALME 10 CeO2 25 mg), 50 mg (ALME 10 CeO2 50 mg). These two fuel blends are tested in Engine.***

Keywords--- ***Alternate Fuel, Bio Diesel, Algae Bio Diesel (ALME), Cerium Oxide Nano Particles.***

I. INTRODUCTION

In any sector energy will plays a key role for economy development in any country. In energy field fossil-based fuels like Coal, Diesel, Petroleum are major sources. The world is facing lot of problems by the usage of fossil-based diesel fuel. Day by day vehicle population is increasing due to human luxury causes an extra usage of fuel at the same time sources are decreasing. i.e. fossil based fuels are non-renewable energy sources. Emissions released by the usage of diesel as a fuel in engine is high. To overcome these problems Bio Diesel is an effective and non-renewable source for replacement of fossil-based diesel fuel. The Bio Diesel is an Alternate fuel derived from the plant-based fat and animal based fat. The oil or fat derived from these sources contains 80 to 90% of Triglycerides, small portion of di-glycerides and mono glycerides. Diesel extracted from fossil sources is a Hydrocarbon fuel contains Hydrogen, carbon and other small elements, does not contains the oxygen. But the oil or fat derived from plant or animals contains oxygen also. The main problem using straight neat oil as a fuel is viscosity. Due to high viscosity the atomization of fuel will be less and causes piston sticky. These problems are rectified by various processes like pre-heating, blend with diesel, micro-emulsion, pyrolysis, addition of alcohol, separation of glycerin by Transesterification process. In the Transesterification process the straight neat oil is reacted with the alcohol in the presence of a catalyst to form esters. If reaction is with ethanol called as ethyl ester, with methanol called as methyl esters.

II. MATERIAL AND METHODS

Material

Algae is cultivated in a pond. Fossil based diesel is obtained from local fuel bunk. The chemicals (Ethanol, Methanol) catalyst (NaoH) is purchased from the local market.

Algae cultivation & Oil Extraction

Algae is cultivated in a pond, pond is constructed with bricks having a dimension of 5x12 ft and covered with tarpaulin. In this pond Algae is cultivated and 950 gm of algae is produced at every time.

For lipid extraction process solvent method, Soxhlet Extraction, Mechanical pressing and Pyrolysis process are used. In the present project Soxhlet Extraction is utilized for lipid Extraction.

Soxhlet extraction is an oil Extraction process by ethanol as a reflux. The soxhlet tube, helical condenser, Round Bottom Flask (RBF) are the apparatus for this process. Initially the RBF is filled with Ethanol of 250 ml. The soxhlet tube with 100 gm of dried Algae. The helical condenser is placed on soxhlet tube; water tubes are connected to the main water supply line. Now this entire set up placed on a Hot plate, the boiling temperature of the ethanol is about 65^0C, the hot plate is set to 70^0C. the ethanol is boiled and evaporated transferred to the condenser. In condenser the ethanol is cool down and poured in to the soxhlet tube. In the soxhlet tube the algae is available, this is submerged in ethanol. If the soxhlet tube is filled get back to the RBF through the Syphon. This cycle is repeated 8 to 10 times. After this process the ethanol is separated by rotary separator.

Manuscript received June 10, 2019.

Narkedamilli Pavan Kumar, Dept.of Mechanical Engineering, P.G Student, Godavari Institute of Engineering & Technology, Rajahmundry, A.P, India. (e-mail: pavankumarm244@gmail.com)

K. Venkateswararao, Dept. of Mechanical Engineering, Assistant Professor, Godavari Institute of Engineering & Technology, Rajahmundry, A.P, India. (e-mail: k.venkat328@gmail.com)

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

III. BIO DIESEL PRODUCTION

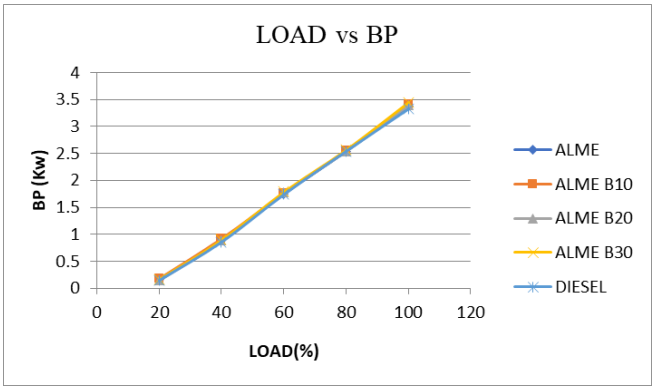
Transesterification process is used for production the Algae Methyl Ester. The Neat and dried algae oil is reacted with 13% of Methanol and 1% NaoH as a Catalyst. The Magnetic stirrer is set to 700 rpm and temperature is set to 70^0C. now this solution is transferred to a separating funnel to separate the glycerin. Methyl ester and post treatment is done to get the salt free and moisture free Bio diesel.

IV. BLENDS PREPARATION

Algae bio Diesel or Algae Methyl Ester is mixed with the fossil-based diesel fuel at very slow stirring rate. The blend is gently stirred for 20 to 30 min and leaved for some time to reach equilibrium condition. The Algae Methyl Ester is mixed with fossil-based diesel fuel with volume basis at a proportion of 10% (ALME 10), 20% (ALME 20), 30% (ALME 30).

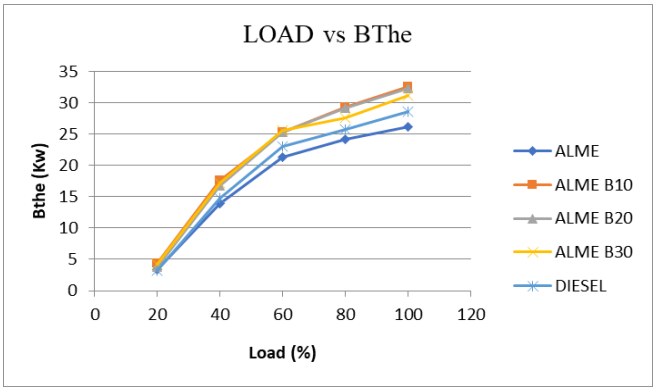
V. RESULTS & DISCUSSION

Performance Analysis for Blends Load vs BP



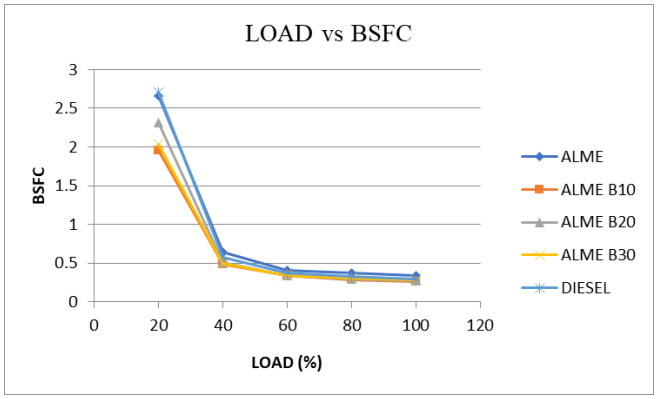
ALME10 is producing highest BP of 3.45kw at 100% load on the engine. At 100% load fossil based diesel is producing a BP of 3.32kw, it is lower than the ALME and its blends. 2.71% of BP is increased for ALME 10 compared to Diesel. The availability of heat energy will cause for power production. The bio diesel contains oxygen, so it is mainly effects on power production. The fossil based diesel having the high heat content but due to non-availability of oxygen in fuel is effecting low power production. By increasing the ALME proportion the availability of oxygen is increased but, heat content is reduced at the same time viscosity is increased. So due to these conditions ALME 10 is producing highest Brake Power.

Load vs BThe



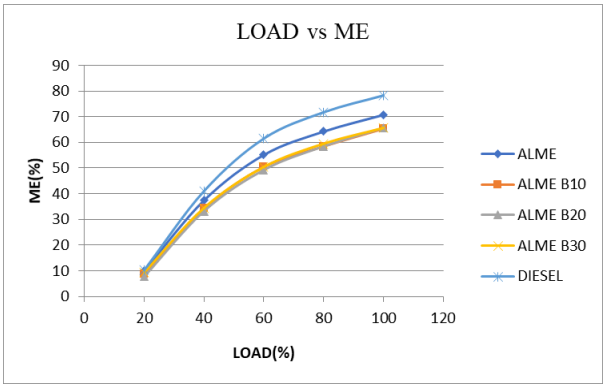
The ALME10 is producing BThe of 32.54% at full load condition which is greater than the all bio diesel blends and Diesel fuel. The fossil based diesel fuel is produced 28.61% of BThe. By using blend ALME 10 the BThe is 13.73% is increased compared to fossil based diesel. The heat content will play a key role in achieving the high BThe. If the ALME content increased in the blend will increases the viscosity causes poor atomization and reduces the BThe.

Load vs BSFC



the blend ALME10 is producing a lowest Bsfc of 0.26 kg/kw-h. The diesel has a Bsfc of 0.3 kg/kw-h, which is greater than the all blends. The ALME is consuming a less BSFC of 13.33%. The specific fuel consumption is decreases with increase in load. The load on the engine causes increase in suction pressure, due to increase in suction pressure the availability of enough oxygen is increased, so proper combustion is takes place.

Load vs ME



The Brake power and Indicated power is co related by Mechanical efficiency. The pure bio diesel ALME have 78.24% which is greater than the all blends. The ALME is having highest viscosity causes enough lubrication between the sliding surface and achieves the highest Mechanical Efficiency.

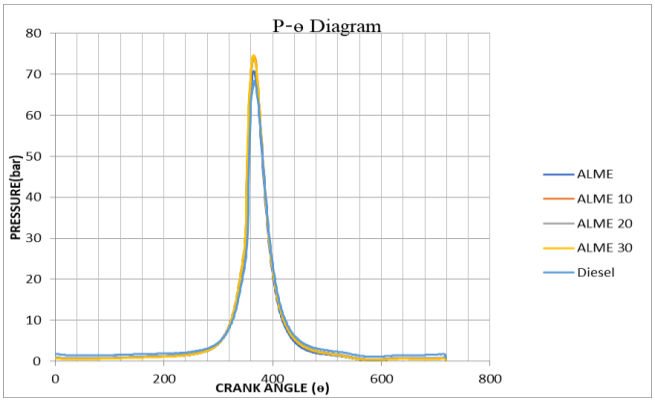
Combustion Analysis for Blends

The CI Engine will have following periods during combustion

I - Ignition Delay.
II - Period of uncontrolled combustion.
III – Period of controlled combustion.
IV – After burning.

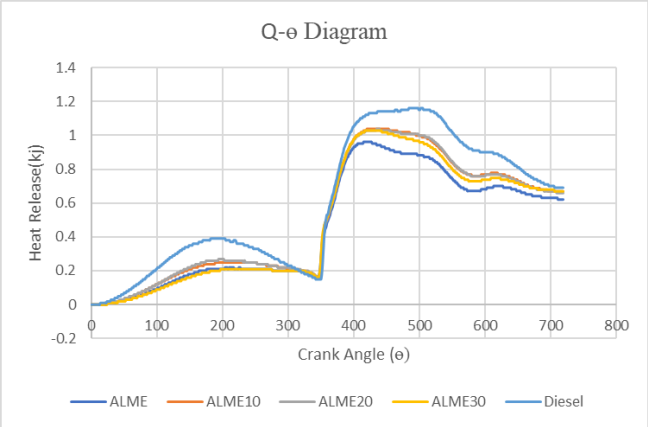
Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

P-ɵ Diagram

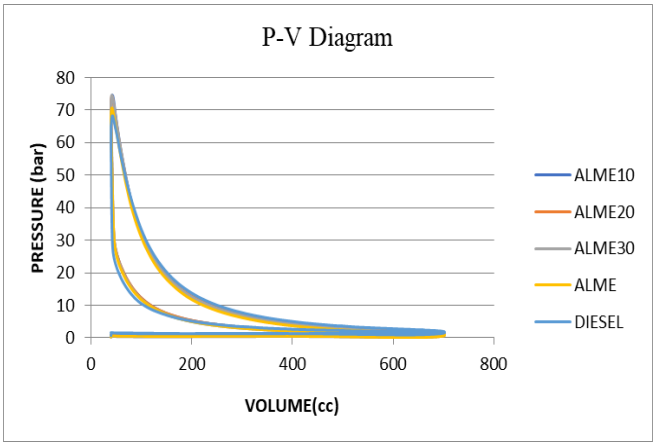


Mode of operation	Start of injection (⁰)	Start of combustion (⁰)	Ignition delay (⁰)	Period of uncontrolled combustion (⁰)	Peak pressure (bar)	Peak pressure angle (⁰)
Diesel	337	355	18	12	68.4	367
ALME	337	347	10	18	70.73	365
ALME 10	337	347	10	20	74.42	367
ALME 20	337	347	10	23	74.39	370
ALME 30	337	346	9	19	74.6	365

Heat Release rate



P-V (Indicator) Diagram



The ALME 30 is have highest peak pressure of 74.6 bar at a crank angle of 365⁰. The ALME 10 have peak pressure of 74.42 bar at 367⁰. The Diesel have a peak pressure of 68.4 bar at 367⁰. The Ignition delay period for fossil based diesel fuel is greater than the bio diesel and its blends and it is about 18⁰. The Diesel is hydrocarbon fuel doesn't contain oxygen. But the bio diesel has oxygen will boost up the rate of reaction and cause for reduction in ignition delay period.

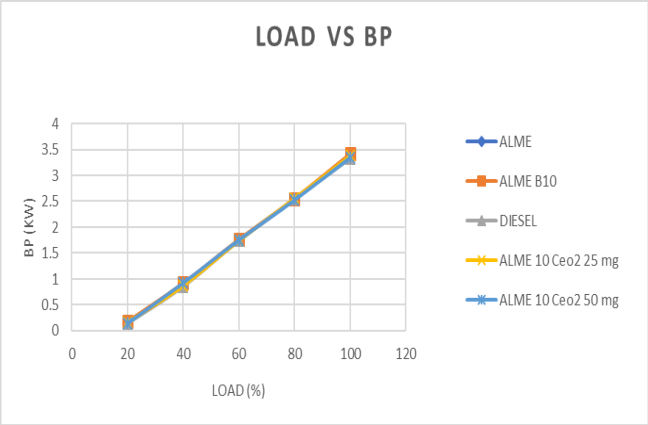
Conclusion for Blends

Based on the performance and combustion analysis the Algae blend ALME 10 is best and achieves high brake power, Brake thermal efficiency and less in Brake specific fuel consumption.

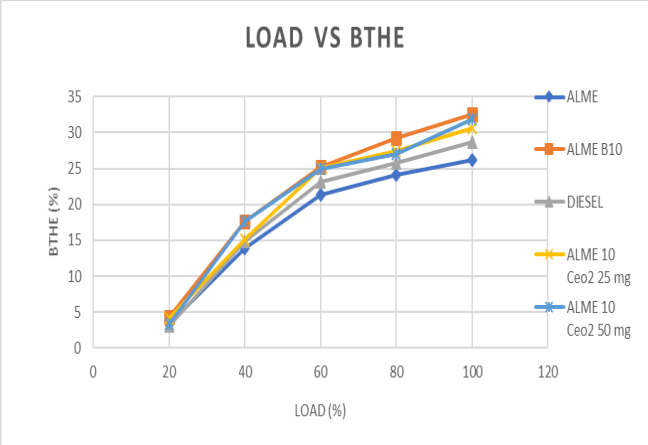
Now the research is towards the Nano particles. For the best blend of algae i.e. ALME 10, cerium oxide is added at 25 mg (ALME 10 CeO2 25 mg) and 50 mg (ALME 10 CeO2 50 mg) for 1 kg of blend. These are tested in engine, obtained results are compared with the Diesel fuel.

Performance Analysis for Metal Oxide Nano Additives

Load vs BP



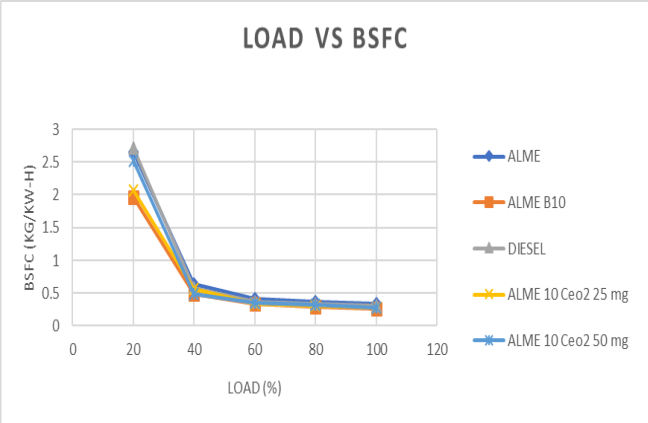
Load vs BThe



The BThe for ALME 10 is 32.54% which is greater than the all other blends. The fossil based diesel is have 28.61% of BThe and it is lesser than the all other operations. The BThe for ALME 10 is increased in 13.73% compared to diesel. The BThe for ALME 10 CeO2 50 mg is increased 10.11% increase compared to diesel.

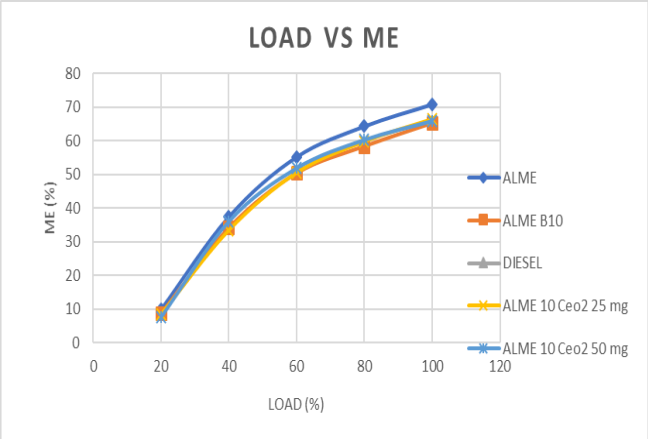
Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

LOAD VS BSFC



The combination ALME 10 achieves less BSFC of 0.26 kg/kw-h. The diesel has a BSFC of 0.3 kg/kw-h, it is greater than the all blends and less than the pure mode ALME. By using ALME 10 the BSFC is reduced in 13.33% and by using ALME 10 CeO2 50 mg the BSFC is reduced in 12.5%.

Load vs ME

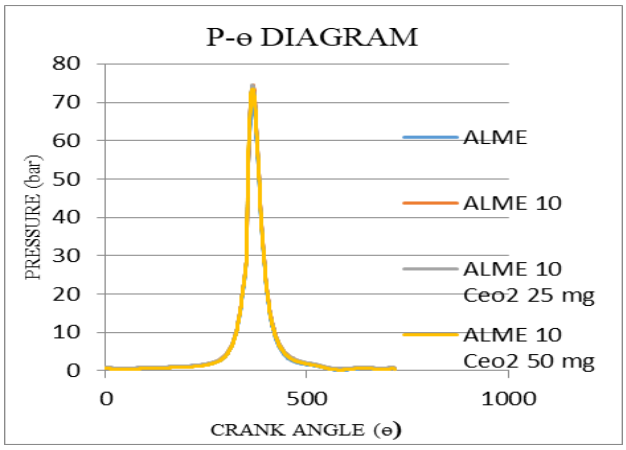


The Brake power and Indicated power is co related by Mechanical efficiency. The pure bio diesel mode ALME having highest ME of 70.84%. due to high viscosity the ALME causes enough lubrication between the rubbing parts inside the combustion chamber and achieves highest mechanical efficiency.

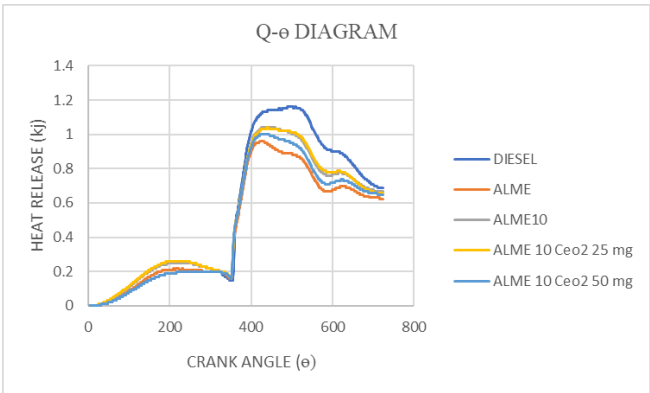
Mode of operation	Start of injection (⁰)	Start of combustion (⁰)	Ignition delay (⁰)	Period of un controlled combustion (⁰)	Peak pressure (bar)	Peak pressure angle (⁰)
Diesel	337	355	18	12	68.4	367
ALME	337	347	10	18	70.73	365
ALME 10	337	347	10	20	74.42	367
ALME 10 25 mg	337	346	9	19	74.4	365
ALME 10 50 mg	337	3-46	9	19	73.46	365

Comustion Analysis for Metal Oxide Nano Additives

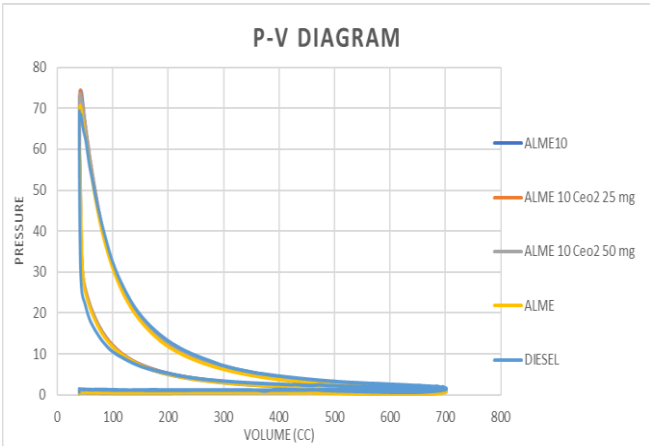
P-ɵ Diagram



Heat Release rate



P-V (Indicator) Diagram

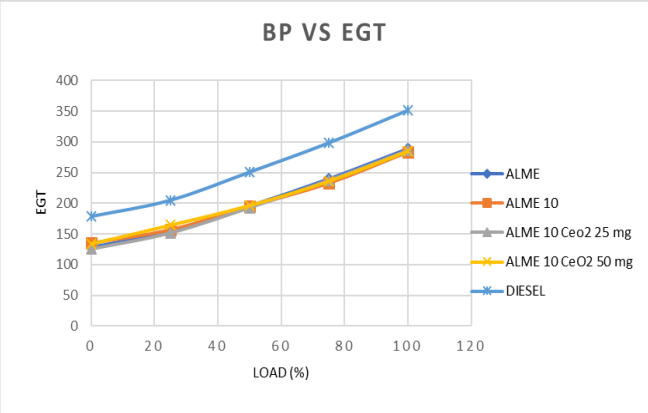


The Blend ALME 10 and ALME 10 CeO2 25 mg are reached a peak pressure of 74.4 bar at a crank angle of 367^0 and 365^0 respectively. The fossil-based diesel fuel mode operation reached a pressure of 68.4 bar and it is less than the bio diesel blends. The addition of cerium oxide nano particle will reduces the ignition delay period of 1^0 of crank angle. The cerium oxide will act as oxygen booster by donating oxygen molecule in lattice structure.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

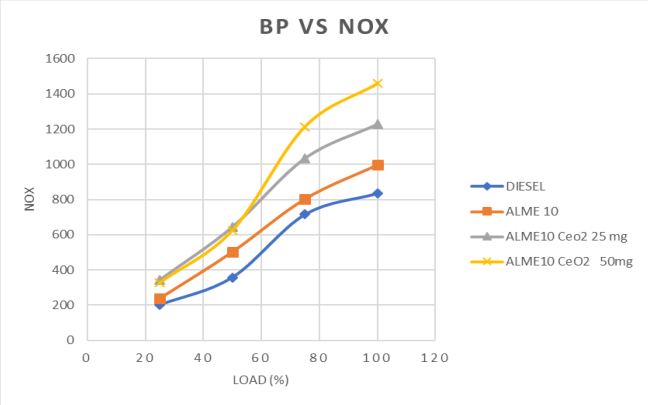
Emission Analysis

BP vs EGT



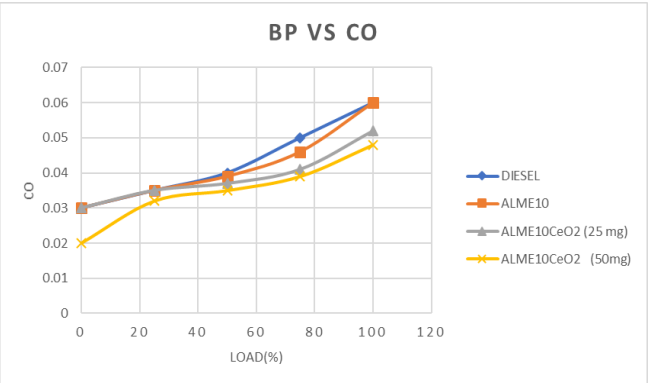
The diesel fuel achieves highest Exhaust gas temperature of 351^{0}C. the blend B 10 CeO2 50 mg have a Lowest temperature of 284.55^{0}C. The heat released during combustion process, after burring period will cause for production of EGT. The addition of CeO2 will increases the oxygen content in the combustion chamber reduces the after burning period and causes for production of less EGT.

BP vs NOx



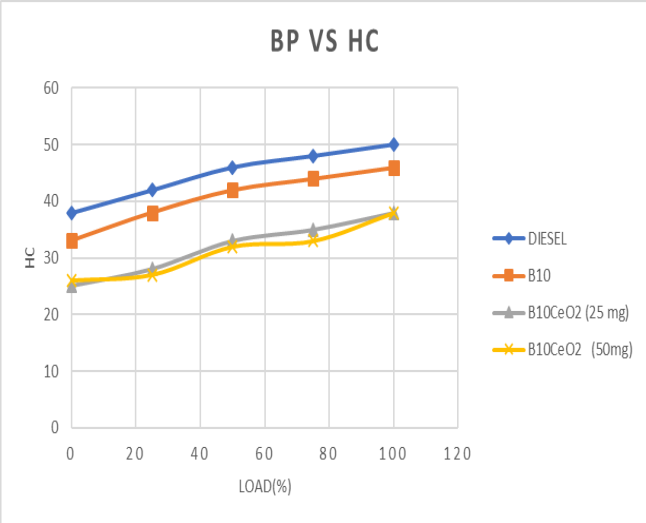
The NOx are produced by production of high temperatures in the combustion chamber. During suction stroke the engine sucks the atmospheric air, this air contains 78% nitrogen and 20% of oxygen. At high temperature the oxygen is reacts with the nitrogen and causes for production of NOx. The ALME 10 CeO2 50 mg is produces 1458 ppm at full load condition. The diesel fuel produces 835 ppm of NOx. The fossil-based diesel fuel produces less NOx, and the blend ALME 10 CeO2 50 mg releases highest NOx.

BP vs CO



During combustion process all carbons are not converted to CO2 due to insufficient oxygen. The blend ALME 10 50 mg produces less CO of 0.48 and blend ALME 10 CeO2 25 mg releases 0.048. the addition of cerium oxide nano particles increase the oxygen content and reaction rate is increased, all carbons are converted to CO2.

BP vs HC



The fossil based diesel is releases the high unburned hydrocarbons of 50 ppm. The blend ALME 10 CeO2 50 mg releases the lowest unburned hydrocarbons of 38 ppm.

VI. CONCLUSION

Algae oil is extracted from the dry algae by soxhlet extraction method by using ethanol as a reflux. The oil yield is about 70%. The produced Algae oil is converted into Methyl ester by transesterification by reacting with methanol and Sodium hydroxide (NaoH) as a catalyst.

The bio diesel is blended at a proportion of 10%, 20%, 30% by volume basis.

The blend ALME 10 achieving required combustion and performance parameters and it is selected as a best blend.

For this blend Cerium oxide Nano particles (CeO2) is added at a proportion of 25 mg and 50mg.

By adding cerium oxide nano particles the emissions HC, CO, EGT are reduced.

So finally, the blend ALME 10 along with cerium oxide nano particles will be suitable for stationary engines.

Future scope

- Same analysis will be done on an automobile engine.
- The oil will be extracted by solvent method by using n-hexane as a solvent.
- The nano particle like alumina, zinc can also investigate.
- The Blends are further blended with the Oxygenated additives like Iso Butyl Alcohol, Iso Amyl Alcohol etc.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

ACKNOWLEDGMENT

Thanks, from bottom of the heart to my research guide Mr.K. Venkateswara Rao, Assistant Professor of GIET, Rajahmundry for supporting and providing project requirements, Mr.R.Sam Sukumar, Associate Professor of SCET, Narsapur for providing necessary equipment and turning to words critical examination of results.

REFERENCES

1. Kumar Patel, H., & Kumar, S. (2017). Experimental analysis on performance of diesel engine using mixture of diesel and bio-diesel as a working fuel with aluminum oxide nanoparticle additive. Thermal Science and Progress, 4, 252–258.
2. Muthusamy, S., Nallathambi, S. S., Ramasamy, R., Thasthagir, S., & Hussain, M. (2017). Effect of aluminium oxide nanoparticles blended pongamia methyl ester on performance, combustion and emission characteristics of diesel engine. Renewable Energy.
3. Khalife, E., Tabatabaei, M., Najafi, B., & Mostafa, S. (2017). A novel emulsion fuel containing aqueous nano cerium oxide additive in diesel – biodiesel blends to improve diesel engines performance and reduce exhaust emissions : Part I – Experimental analysis. Fuel.
4. Sajeevan, A. C., & Sajith, V. (2016). Synthesis of stable cerium zirconium oxide nanoparticle – Diesel suspension and investigation of its effects on diesel properties and smoke. Fuel, 183, 155–163.
5. Chaichan, M. T., Kadhum, A. A. H., & Al-amiery, A. A. (2017). Novel Technique for Enhancement of Diesel Fuel : Impact of Aqueous Alumina Nano-Fluid on Engine' s Performance and Emissions To appear in : Case Studies in Thermal Engineering. Case Studies in Thermal Engineering.
6. Vairamuthu, G., Sundarapandian, S., Kailasanathan, C., & Thangagiri, B. (2015). Experimental investigation on the effects of Cerium oxide nanoparticle on Calophyllum inophyllum (PUNNAI) biodiesel blended with diesel fuel in DI diesel engine modified by nozzle geometry. Journal of the Energy Institute.
7. Minowa, T., Yokoyama, S., & Kishimoto, M. (1995). Oil production from algal cells of Dunaliella t e r t i o l e c t a by direct thermochemical liquefaction, 74(12), 1735–1738.
8. El-araby, R., Amin, A., Morsi, A. K. El, El-ibiari, N. N., & El-diwani, G. I. (2018). Study on the characteristics of palm oil – biodiesel – diesel fuel blend, 27, 187–194.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication