EVALUATION OF PERFORMANCE AND EMISSION CHARACTERISTICS OF MAHUA OIL AND COTTON SEED OIL BIODIESEL BLENDED WITH ALUMINIUNM OXIDE NANO ADDITIVE WITH CRDI ENGINE

K. MADDILETY, P.G Research Scholar, Department of Mechanical Engineering, J.N.T.U.A College of Engineering (Autonomous), Ananthapuramu, A.P, India.
Dr B. CHANDRA MOHANA REDDY, Professor & Controller of Examination, Department of Mechanical Engineering, J.N.T.U.A College of Engineering (Autonomous), Ananthapuramu, A.P,

ABSTRACT: *In this paper the Analysis and comparison of the oil's characteristics with that of diesel products revealed similarities between the two oils made from cotton seed and mahua oil. The use of mahua oil, and cotton seed oil, biodiesels are as a fuel for diesel engines will produce the best results after combustion, according to a brief review provided in this study. Each variety of mahua and cotton seed oil will be prepared for trans-esterification. Discussion follows the findings of experimental tests on a diesel engine. Environmental pollution and problems with fossil fuel inanition are major global problems. All autos emit a significant amount of hazardous gas emissions that are released into the atmosphere. Vehicle emissions are recognized to have a negative impact on air quality, thus it's important to limit environmental pollution for both human health and the ecosystem. This study's major objective is to add octanol to mahua oil biodiesel to lower its varied emissions. This study found that adding octanol in various quantities to biodiesel, mahua oil, cotton seed oil, and other additives significantly reduced all of the emissions. It is necessary to assess the combustion parameters such as ignition, delay, peak pressure, rate of pressure, and exhaust emissions such as CO, CO2, HC, NOx, and smoke emissions.*

Keywords--- Biodiesel, Mahua, cotton seed oil, Transesterification, Aluminum oxide

1.INTRODUCTION

The world's petroleum reserves are gradually being depleted as a result of population growth and rising energy demand from the transportation sector. The majority of internal combustion engines use fossil fuel-based diesel fuel to power them. The use of diesel fuel in IC engines contributes to pollution, global warming, and health risks. Biodiesel may be assured of a sustainable market in India to satisfy our requirement. Vegetable/plant oils and esters become the emphasis as a result. The non-edible bio fuel is seen to be the most viable option because it doesn't require any acreage that produces food.
The main issues with using straight vegetable oil (SVO) as a substitute for petroleum diesel in CI engines were its high viscosity, low volatility, and

polyunsaturated nature. Vegetable oils' enormous molecular weight and chemical makeup are to blame for these issues. Vegetable oils are known to create gums, injector deposits, and ring sticking in long-term processes because to their polyunsaturated nature.
aluminium oxide is a combination of aluminium and oxygen. It is precisely referred to as aluminium oxide and is the variety of aluminium oxides that occurs most frequently. According to certain forms or uses, it may alternatively be referred to as aloxide, aloxite, or alundum in addition to the name alumina. It naturally occurs as the mineral corundum, which has the variants that make up the priceless gemstones ruby and sapphire.
The oxygen concentration in biodiesel, which is typically absent from diesel fuel, is a significant characteristic. Biodiesel significantly reduces PM carbon monoxide (CO) and hydrocarbon (HC) emissions without increasing fuel consumption or degrading engine performance.

2. Literature Review

Cotton seed oil and diesel blend fuel were used in an experiment by Nabi et al. [1] on a single cylinder, four-stroke diesel engine. The results showed that adding 10% biodiesel to diesel improved CO and HC emissions while maintaining nearly constant efficiency and fuel consumption.

Cotton seed biodiesel was evaluated in diesel engines by Aydin & Bayindir et al. [2], who came to the conclusion that while there is a noticeable improvement in emission characteristics, the variance in thermal efficiency is negligible up to 15% biodiesel blend.

According to research by Karabektas et al. [3] on the impact of preheated cotton seed oil on the efficiency and emissions of diesel engines, preheating cotton seed oil to 90°C results in the best efficiency and emissions.

According to Bora et al. [4], the presence of more oxygen in fuel causes a combustion chamber to produce more heat during the pre-mixed phase, which significantly contributes to an increase in NOX emissions.

3.MATERIALS

3.1 MAHUA OIL EXTRACTION

Mahua oil has been shown to be the most effective for producing biodiesel because it is rich in mono unsaturated fatty acids and low in saturated and polyunsaturated fatty acids..

Fig.1 Raw mahua oil

Fig. 2 mahua oil seeds

3.2 COTTON SEED OIL

Cottonseed oil, a widely used vegetable oil, is produced from the cotton plant's seeds. About 15–20% of each entire cotton seed is oil. The refined seed oil that is produced from the kernels can be used as a cooking oil. The cotton species known as Gossypium arboretum, sometimes known as tree cotton, is indigenous to Bangladesh, and other tropical and subtropical areas.

Fig.3 Cotton seeds

Fig.4 Raw cotton seed oil

4.METHODOLOGY

TRANSESTERIFICATION

The process of turning tri-glycerides into mono esters and glycerine while there is alcohol present is known as trans esterification. prepared oil from a previous step that is currently ready. Fatty acids that have been trans esterified into mono esters

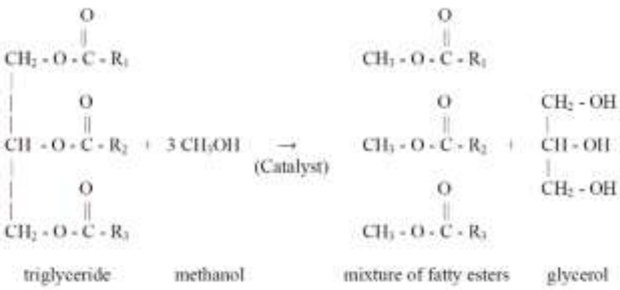


Fig 6. mechanism of methanol transesterification

If the FFA value is
< 4-One way Trans esterification
>4-two-way Trans esterification.
Since the FFA is closely higher a two-way Transesterification process is decided to convert the non-edible blended oil to its methyl ester.

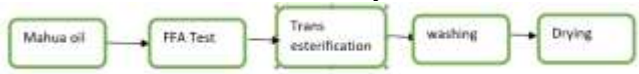


Fig 6. Flow chart of Bio Diesel production

4.1. Acid Catalyzed Transesterification

In the first step of acid-catalyzed esterification, 1 litre of hybrid blended oil is heated to approximately 60 °C in a 3-neck beaker. 150 ml of methanol and 1 ml of concentrated H2SO4 are then added to the heated hybrid oil, and the mixture is stirred continuously at 65 °C for approximately one and a half hours using a magnetic stirrer. The solution is allowed to settle in a separating funnel for 3–4 hours after the reaction is finished. It happens that layers are formed. Excess alcohol, sulphuric acid, and other pollutants are generated in the top layer, which is then removed. The second stage involves removing the bottom layer (alkaline esterification).

Fig 5. Magnetic stirrer

Fig 6. Methanol with H_2so_4

4.2Alkaline catalyzed Trans esterification

The first step's output is changed into mono-esters and glycerol in the second step's alkaline catalysed transesterification process. Once more heated to between 65 and 70 °C, the first step's lower layer result. 150 ml of methanol containing 7.5g of sodium hydroxide are added to this mixture and agitated for 1.5 hours. The reaction is finished, and the solution is then given another 3–4 hours to settle. Glycerin sinks to the bottom, while esterified mixed oil rises to the surface.

Fig 7. Alkaline tars esterification

4.3. water wash method

The water wash method is a process used to separate and wash this esterified mixed oil using de-Ionized water. The finished product is heated to 120 °C for 30 minutes after filtration, and it is then cooled to room temperature. Glycerin that has been obtained is utilised to make organic soap. To produce biodiesel, the residual diesel is heated for demoisturization.

Fig 8. Removing Di-ionized water

Fig 9. Bio diesel

4.4 Nano Additive

Nano additives are tiny particles that have been designed to enhance the qualities of biodiesel and make it more competitive with diesel. The surface is where the heterogeneous reaction takes place. Compared to their mass, nanoparticles have a far larger surface area. It increases the number of response locations where the reaction can occur. The surface particle is more responsive and unstable. atoms proportion increases. Subsequently. Due to their small size, they can certainly be blended with biodiesel. When combined with biodiesel, it increases efficiency, reduces emissions, and completely ignites the biodiesel.

4.5. Aluminium oxide:

To improve the characteristics of biodiesel fuel, such as calorific value, cetane number, oxygen content, and reduction in ignition delay time. The biodiesel was mixed with Nano-additives by several researchers. According to earlier studies, the short-term stability of metal-based nano-additives led to the agglomeration, clustering, and settling of nanoparticles. Aluminum oxide is used as a nanoparticle in the current experiment.

Fig 10. Aluminium oxide

Fig 11.microweighing machine

4.6. properties of Aluminium oxide

Table 1.properties of Aluminium

Aluminium oxide	Description
Purity	90%
Thickness	2-4 nm
Oxygen content	40-47%
Surface area	280-600m^2/g
Physical form	Fluffy, white powder

By using the co-precipitation method at various annealing temperatures, aluminium oxide has been created. According to the scherer formula, powder XRD supports the production of a-al 2 o 3, which has a rhombohedral crystal structure with lattice constants of a d 4.76 a and b d 12.99 a. The average crystallite size is calculated to be 66 nm.

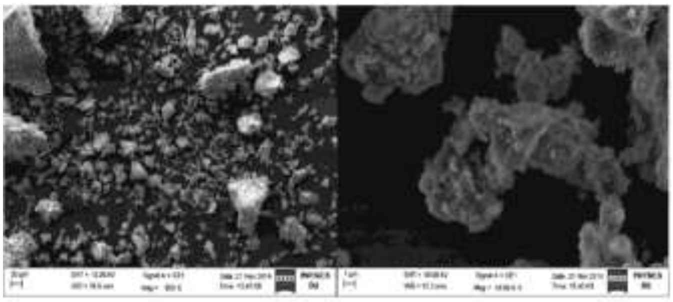


Fig 12. sem analysis of Aluminium

5.ENGINE SETUP

The system includes an eddy current dynamometer coupled to a single-cylinder, four-stroke CRDI VCR engine. It has the tools it needs to measure load, temperature, airflow, fuel flow, crank angle, combustion pressure, and crank angle. A high-speed data acquisition device interfaces these signals with the computer. The system features a stand-alone panel box with an air box, two fuel tanks, a manometer, a fuel measuring unit, transmitters for measuring the flow of both air and fuel, a process indicator, and a piezo powering unit. Water flow measurement rotameters are available for calorimeters and engines. The CRDI VCR engine has a programmable Open ECU for Diesel Injection, a fuel injector, a common rail with a rail pressure sensor and pressure regulating valve, a crank position sensor, a fuel pump, and a wiring harness. With a programmable ECU and various compression ratios and EGRs, the arrangement makes it possible to investigate the performance of a CRDI VCR engine. Engine performance analysis covers the following factors: air fuel ratio, heat balance, combustion analysis, mechanical efficiency, volumetric efficiency, brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency.

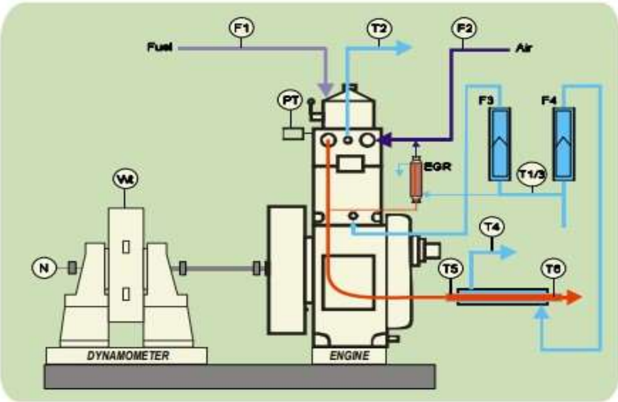


Fig 13. Line diagram of CRDI engine

Fig 14. CRDI engine with dynamo meter

5.1 ENGINE DETAILS

Table 2. Engine details

Specification	Type
Power	3.50kw
Speed	500rpm
Cylinder	1
Stroke	4stroke with 110mm
Type of cooling	Water cooled diesel engine
Cylinder bore	87.50mm
Connecting rod length	234mm
Swept volume	661.45cc
Compression ratio	18.00

5.2 EXPERMENTAL PROCEDURE

The following are the various steps in the experimental investigations:

1. Currently, research is being done on diesel and hybrid oils (made from mahua and cotton seed).

5. The following blends as a fuel in the engine.

   i.B10(10% Hybrid + 90% Diesel) + 40ppm Aluminium oxide

   ii. B20 (20% Hybrid + 80% Diesel) + 40 ppm Aluminium oxide

   ii. B30 (30% Hybrid + 70% Diesel) +40 ppm Aluminium oxide.

2. Make a note of the values for various mixes under various loading situations. Circulating water through the engine's cylinder head and block jackets allows the engine to cool down. The main gaseous emissions in the experimental investigations were measured to be HC, CO, CO2,02, and NOX.

5.3 Properties of bio diesel blends with aluminium oxide Nano additive

Properties of bio diesel blends with aluminium oxide Nano additive

Table: 3 Properties of hybrid fuel

Property	Diesel	B10+D90+ Al_2o_3 (40PPM)	B20+D80+ Al_2o_3 (40PPM)	B30+D70+ Al_2o_3 (40PPM)	ASTM standard
Density (kg/m^3)	835	840	845	850	ASTM6751
Calorific value (kj/kg)	42700	42300	41900	41500	IS:1448(P6)
Kinematic Viscosity (Cst)	3.8	3.86	3.92	3.92	ASTMD445
Flash point(^{0}C)	72	80.8	89.6	98.4	IS1448

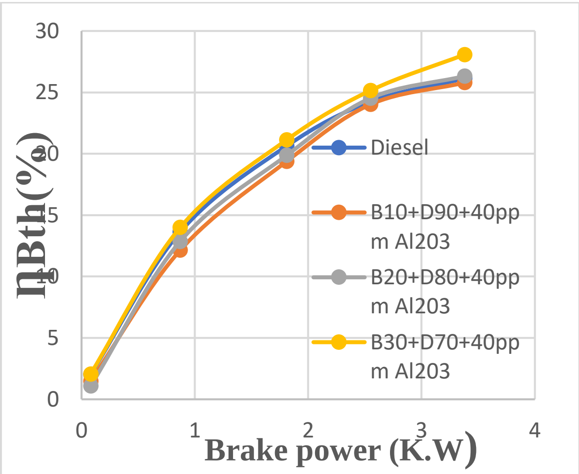
6. Result and discussions

In this paper we are investigated the performance and emission characteristics of biodiesel blends conducted on Single cylinder compression ignition engine and compared with pure diesel

The performance characteristics of C1 engine are

1. Brake thermal efficiency
2. Brake specific fuel consumption
3. Mechanical efficiency
4. Indicated thermal efficiency

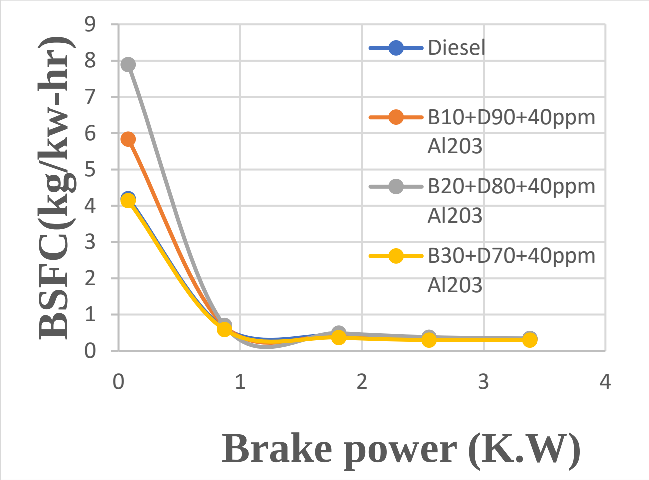
6.1 Brake Thermal efficiency



Graph 6.1 BP VS Brake Thermal efficiency

Brake thermal efficiency is defined as ratio of brake power energy to the input fuel energy in appropriate units. Variation of brake thermal efficiency along with pure diesel and blends of biodiesel at different loads condition are shown and the results obtained pertaining to the performance of the engine is demonstrated with the help of graphs. The variation of brake thermal efficiency with brake power for diesel fuel and biodiesel blends B10, B20, B30 with 40ppm of AL_2O_3in each blend It has been observed that the brake thermal efficiency of the blends is increasing with increase in applied load because of reduction in heat loss and increase in power developed with increase in load. By increasing the load of the engine, the brake thermal efficiency also increases for all the blended fuel tested. At full load brake thermal efficiency of diesel fuel is 26.14, brake thermal efficiency for D70+B30+40PPM of $AL_2O_3$is 28.08 which is 7.42% higher than the diesel, for blends of B10 and B20 it is 25.79% and 26.32% respectively. By increasing the load of the engine, the brake thermal efficiency also increases for all the blended fuel tested.

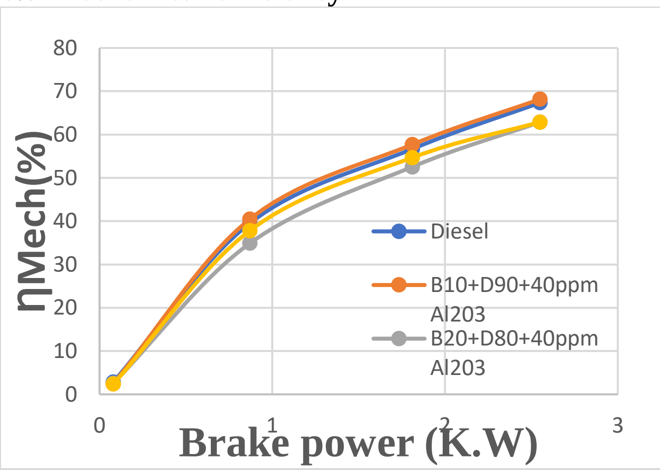
6.2 Brake specific fuel consumption



Graph 6.2 Brake specific fuel consumption

BSFC may be defined as ratio of amount of the fuel consumed to produce for unit Brake Power. Otherwise, Brake- specific fuel consumption (BSFC) is the ratio between mass fuel consumed per brake effective power, and for a given fuel, it is inversely proportional to thermal efficiency. BSFC decreased sharply with increase in load for all fuels. The main reason for this could be that the percent increase in fuel required to operate the engine is less than the percent increase in brake power, because relatively less portion of the heat is lost at higher loads. The variation of brake specific fuel consumption with brake power for diesel fuel, biodiesel blends B10, B20, B30 with 40PPM of AL_2O_3 in each blend are shown below. The brake thermal efficiency of blends increasing with the load of the engine, the brake specific fuel consumption decreases for all the blended fuel tested. At full load brake specific consumption of diesel (0.34kg/kw-hr) which is equal to B20+D80+40PPM of AL_2O_3 blend for B10 and B20 blends. Brake specific fuel consumption is 5.8% and 11.7% less than the diesel respectively.

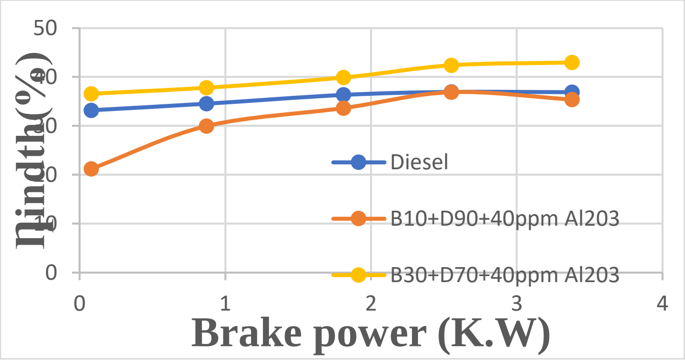
6.3 Mechanical efficiency



Graph 6.3 Brake power vs mechanical efficiency

The variation of Mechanical Efficiency with Brake power for different blends. From the graph that the Mechanical Efficiency is high for diesel, biodiesel blends have less mechanical efficiency due to higher viscosity of the bio diesel. at full load mechanical efficiency is 72.44% for B10+D80+40PPM of the AL_2O_3IS 72.9%. which is 0.635% Higher than the diesel, for blend B20 and B30 mechanical efficiency values are 5.9%, and 6.26% less than Mechanical efficiency of diesel respectively.

6.4 Indicated thermal efficiency



Graph 6.4 Brake power vs Indicated thermal

Indicated thermal efficiency:

Indicated thermal efficiency is the kind of engine thermal efficiency that is given by the ratio of indicated power generated by the engine to the power generated by the combustion of the fuel. It states the amount of power taken by the piston out of the total fuel power. below figure indicates the variation of indicated thermal efficiency with respect to brake power for diesel fuel and bio diesel blends of B10, B20 and B30 with 40PPM of AL_2O_3 in each blend. It is observed that indicated thermal efficiency decreases with increasing load. At full load indicated thermal efficiency 36.9% for B30+D70+40PPM of the AL_2O_3 is 42.97% which is 16.4% more than the diesel for blends B10 and B30 values of indicated thermal efficiency 4.0% less than and,4.06% more than diesel respectively.

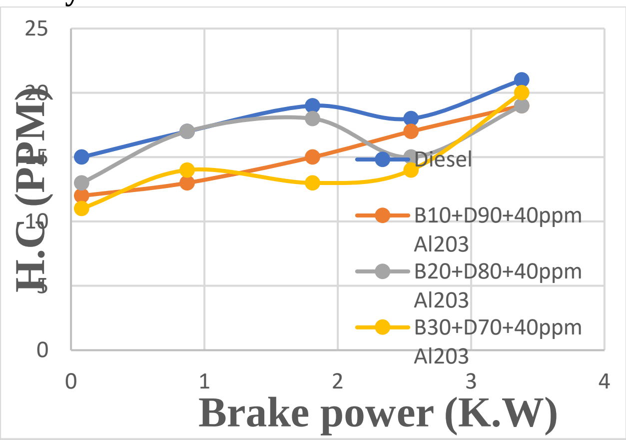
Emission Characteristics

IC engines produce undesirable emissions after the completion of combustion process. The emissions exhausted into the surroundings pollute the atmosphere and causes global warming acid rain, respiratory problems.

In the early investigation several researchers designed engine modification and fuel enhancement for proper and complete combustion to reduce the emission parameters. Some of the emissions which are majorly released during the combustion of engines are

1. Unburnt Hydrocarbons (HC)
2. Oxides of Carbon (CO & CO)
3. Oxides of Nitrogen (NOx)

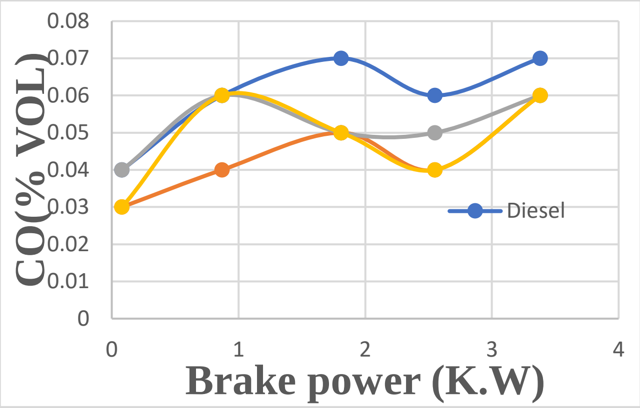
6.5Hydro carbon emission



Graph6.5 Brake power vs hydro carbons

Hydrocarbon emissions (HC), the above graph shows the HC Emissions with conventional diesel and biodiesel blends of B10, B20 and B30 with 40PPM of AL_2O_3. It is obvious from the graph that HC emission decreased with increasing loads. for bio diesel blends hydro carbon emissions are reduced as compared to diesel because of more oxygen presenting bio diesel. At full load hydro carbon emission value of diesel for B10+D90+40PPM of AL_2O_3, Hydrocarbon emission value 19 which is 9.5% less than the diesel and for B20 and B30 hydrocarbon emissions are 9.5%,4.4%lesser than diesel hydro carbon value at full load respectively

6.6 CO Emission

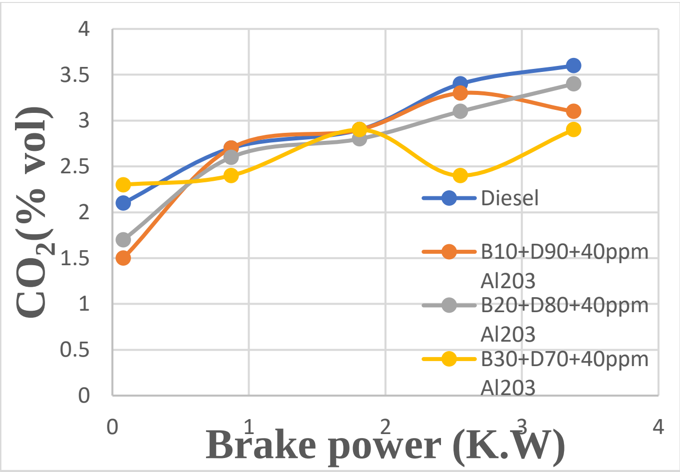


Graph 6.6 Brake power VS Carbon Monoxide

Carbon Monoxide

The most common source of carbon monoxide is the partial combustion of carbon-containing compounds, when insufficient oxygen is present during combustion process carbon monoxide. There are also numerous environmental and biological sources that generate and emit a significant amount of carbon monoxide. It is important in the production of many compounds, including drugs, fragrances, and fuels Upon emission into the atmosphere, carbon monoxide affects several processes that contribute to climate change from below figure observed that carbon monoxide reduced with increasing load because of high oxygen content present in the AL_2O_3nano particles which leads to complete combustion. At full load carbon monoxide emission for diesel is 0.07% The volume for B20+D80+40PPM for AL_2O_3. The volume is 0.06 which is 14.28% lower than diesel. The hydrocarbon emission values for B10 and B30. 14.28% lower than the diesel value at full load respectively.

6.7 CO_2 Emission

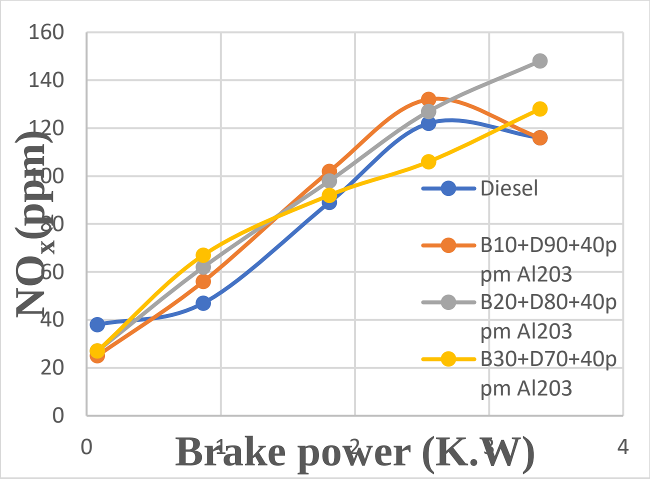


6.7 Graph Brake power VS Carbon Dioxide

CARBON DIOXIDE (CO2):

Carbon dioxide emissions (CO2) of engine is the indication of complete combustion taking place inside the engine cylinder carbon dioxide one of greenhouse gases which causes sever health impacts above figure shows variation of carbon dioxide with respective brake power. It is observed that the values of carbon dioxide emissions are increasing with brake power. It is because of complete combustion taking place at full load. At full load for diesel 3.6% for B30+D70+40PPM of AL_2O_3 is 2.9% of values 19.4% less than the diesel at full load for blend B10 and B20 carbon dioxide emission are 8.3%and 5.5% lower than diesel respectively.

6.8 NOx Emission



6.8 Graph Brake power VS Nitrogen Oxide

NITROGEN OXIDE (NOX)

Nitrogen oxide emissions (NOx), produce from the oxygen due to nitrogen intake air react with oxygen at higher temperature oxides of nitrogen are one of the polluted which causes smokes which causes sever health impact nitrogen oxide emission are reasons for ozone depletion. Below figure shows variation of nitrogen oxides emission with respective brake power. It is observed that non emission of bio diesel because of complete combustion takes place inside engine cylinder and more oxygen content present in the bio diesel. At full load NOx emissions for diesel is 116PPM and for B20+D80+40PPM of AL_2O_3,It is ppm which is 148PPM is 27.5% more than the diesel. For blends B10 and B30 the value of NOx emission of and 9.3% more than the diesel respectively.

7.CONCLUSION

In the current investigation, the conclusion is based on the experimental results obtained while operating on a single cylinder 4-stroke CRDI water cooled Compression Ignition engine using blends of mahua oil and cotton seed oil with aluminum oxide as nanoparticle performance and emission characteristics were studied.

- A marginal increase in Brake Thermal Efficiency (BTE) of for B30+D70+40PPM of $AL_2O_3$is 28.08 which is 7.42% higher than the diesel, was observed with the addition of aluminum oxide nanoparticles to biodiesel blend of B30-40ppm aluminum when compared with pure diesel This is due to availability of more oxygen which tends to complete combustion,
- The brake thermal efficiency of blends increasing with the load of the engine, the brake specific fuel consumption decreases for all the blended fuel tested. At full load brake specific consumption of diesel (0.34kg/kw-hr) which is equal to B20+D80+40PPM of AL_2O_3 blend for B10 and B30 blends. Brake specific fuel consumption is 5.8% and 11.7% less than the diesel respectively.
- The Mechanical Efficiency is high for diesel, biodiesel blends have less mechanical efficiency due to higher viscosity of the bio diesel. at full load mechanical efficiency diesel is 72.44% for B10+D80+40PPM of the AL_2O_3IS 72.9%.
- Hydro carbon emissions are reduced as compared to diesel because of more oxygen present in bio diesel. At full load hydro carbon emission value of diesel for B10+D90+40PPM of AL_2O_3, Hydrocarbon emission value 19 which is 9.5% less than the diesel at full load.
- Carbon monoxide emission for diesel is 0.07% The volume, for B20+D80+40PPM for AL_2O_3 carbon monoxide value is 0.06% of volume which is 14.28% lower than diesel at full load.
- Carbon dioxide emissions are increasing with bra2ke power. It is because of complete combustion taking place at full load. At full load for diesel, it is 3.6% of volume for B30+D70+40PPM of AL_2O_3 is 2.9% of volume which is 19.4% less than the diesel at full load for blend B10 and B20 carbon dioxide emission are 8.3%and 5.5% lower than diesel.

- NOx emissions for diesel is 116 PPM and for B20+D80+40PPM of AL_2O_3, is which is 148 PPM is 27.5% more than the diesel. For blends B10 and B30 the value of NOx emission of and 9.3% more than the diesel.

From the above studies, a concluded that Mahua and Cotton seed oil, biodiesel blend with addition of Aluminum oxide as a Nano additive. (B30+D70+40PPM of AL_2O_3) shows better results when compared with diesel and other biodiesel blend However biodiesel, Blends B20+D80+40ppm Aluminum oxide and B30+D70+40ppm Aluminum oxide shows marginally lower HC, CO, CO2 emissions and increases in more NOx emission comparatively with diesel. In order to minimize the emissions.

References

[1] R. Senthil Kumar, R.Manimaran, “Performance And Emission Character- istics On4-Stroke Single Cylinder C. I. Engine Using Cottonseed Bio Fuels” ISSN-2319–2100

[2] Lalit Sharma, N.K. Grover “,Comparison of Engine Performance of Mixed Jatropha and Cottonseed Derived Biodiesel Blends with Conventional Diesel” ISSN No. 0975-8364

[3] Subramanian, K. A., Singal, S. K., Saxena, M., & Singhal, S. 2005 Utilization of liquid biofuels in automotive diesel engines: an Indian perspective. Biomass and Bioenergy, 29(1), 65-72.

[4] Nabi, M. N., Rahman, M. M., & Akhter, M. S. 2009 Biodiesel from cotton seed oil and its effect on engine performance and exhaust emissions. Applied thermal engineering, 29(11-12), 2265-2270.

[5] Aydin, H., & Bayindir, H. 2010 Performance and emission analysis of cottonseed oil methyl ester in a diesel engine. Renewable Energy, 35(3), 588-592.

[6] Karabektas, M., Ergen, G., & Hosoz, M. 2008 The effects of preheated cottonseed oil methyl ester on the performance and exhaust emissions of a diesel engine. Applied Thermal Engineering, 28(17-18), 2136-2143.

7] 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.

[8] V. Vibhanshu, A. Karnwal, A. Deep, N. Kumar, Performance, emission and combustion, analysis of diesel engine fueled with blends of Mahua oil methyl ester and diesel. SAE Technical Paper Series [Internet], SAE International, 2014.

[9] Performance and emission analysis of ci engine on mahua oil biodiesel. 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.

[10] 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.

[11] Abu-Zaid, M. 2020 January Evaluating the impact of using various biodiesel blends on the performance of diesel engine at variable load conditions. In IOP Conference Series: Materials Science and Engineering Vol. 715, No. 1, p. 012068. IOP Publishing.

[12] Rajesh, S., Banpurmath, N. R., Kulkarni, B. M., & Kumarappa, S. 2020 Performance, emission and combustion characteristics of a multicylinder common rail direct injection diesel engine fuelled with ethanol-acid oil methyl ester-diesel blends. Biofuels, 11(1), 109-120.

[13] Shrivastava, P., & Verma, T. N. 2020 An experimental investigation into engine characteristics fueled with Lal ambari biodiesel and its blends. Thermal Science and Engineering Progress, 17, 1003