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Effect of Al_2O_3 Nano Additive on Combustion, Emission and Performance Characteristics of the Dairy Scum Biodiesel Blend fuelled Diesel Engine

[1]Naveena Kumar R. R., [2]Dhananjaya D. A., [3]D. K. Ramesha, [4]Dr. D. Madhu

[1]Assistant Professor, Dept. of Mechanical Engg., SJB Institute of Technology, Bengaluru, India

[2]Professor & Head, Dept. of Mechanical Engg., Rajeev Institute of Technology, Hassan, India

[3]Associate Professor, Dept. of Mechanical Engg, UVCE, Bangalore, India.

[4]Professor & Head, Dept. of Mechanical Engineering, Govt. Engg. College, Ramanagara, India

[1]naveenmech415@gmail.com3

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Abstract

The Diesel engine is one of efficient engines among all internal combustion engines. Conventional fossil fuels cause more pollution and fossil fuels are in depleting stage this leads to search for environmentally friendly and renewable alternative source of fuels. Biodiesel is the alternative sources for diesel fuel, Biodiesel can also be used in Internal combustion engine without major modifications and biodiesel virtually not contains Sulphur and use of biodiesel in a Diesel engine results reduction in unburned hydrocarbons and carbon monoxide but main drawbacks of biodiesel is high density, less amount of heat produced during burning of fuel, more fuel consumption compared to diesel and high oxides of nitrogen emission compare to diesel fuel. To overcome this draw back various additives are used with biodiesel. Due to their special properties of additives like higher thermal conductivity, chemical properties promote better combustion this causes reduction in emissions and enhance the performance of Diesel fueled engine.

In the experimental work evaluated Emission and Performance of Al_2O_3 Nano particles additives of different proportion (50ppm, 100ppm and 150ppm) with Dairy scum Biodiesel blend of B20. Experimental investigation has been proved that the addition of Al_2O_3 Nano additive with Dairy scum Biodiesel B20 enhance performance and combustion parameters compare to B20 blend and reduces HC, CO emissions with Marginal Increases in NO_X.

Index Terms- Biodiesel, Additives, Performance, Combustion, Emissions.

1. INTRODUCTION

Efficient use of natural and local resources is the basic requirements for the country to become independent and self sustainable which leads to economic growth of the country. Fossil fuel are is in depleting stage for next generation many research have been carried out to develop new agricultural based and renewable based alternative fuels, which will provide

alternative sustainable solution for energy demands.

Fossil fuels are containing more hydrocarbons, which can be burned and used as a source for heat energy. Fossil fuels are found in the Earth crust, globally more carbon emissions contributor are the fossil fuels by human activates. The various literatures reviews shows a reduction in exhaust emissions with the dispersion of oxygenating additives in diesel and bio diesel blends due to their beneficial properties like combustion characteristics, lower aromatic compounds.

The world demand of energy is rapidly increasing. We are using fossil fuels mainly in transportation sector and industries. In the present modern life style energy consumption is keep on increasing as machines are the part of our life style and needs, One of the main energy sources is coal and oil power plants contribute more than alternative sustainable energy sources and rate of production is expected to more in the upcoming years. Biodiesel is a biodegradable, clean burning easy combustible fuel derived fuel from natural and waste resources waste oils like Dairy scum, jatropa vegetable oils and animal fats. These fuels are meet standards specifications these fuels can be blended with fossil fuel as additive these are recommended by environmental agency. Biodiesel can be used in any internal combustion engines in either its pure form, which is referred to neat biodiesel, or it can blended in any concentration with regular petroleum fuels.

2. LITERATURE REVIEW

Various Investigations done on the diesel and biodiesel characteristics by adding the biodiesel with various additives. Nanoparticles of Metal oxide are enhance the engine efficiency and burning properties and reduce the emissions of the engine. It is show that the additives like aluminium oxide Nano particles be the most suitable additive for biodiesel blends. However, still more investigations are in progress to reduce the possible amount of harmful exhausts of engine in order to safe guard the surrounding environment from pollution [1]. Nanoparticles catalysts mix with the diesel fuel to improve their performance and reduce harmful exhaust emission was noticed in the research works [2]. The inclusion of aluminium nanoparticles to the blend reduced the delay period and accelerate the flame propagation process, it led to a reduction in maximum heat release rate [6]. Aluminium particles are best Nano metal oxide additives for enhance the thermal performance, combustion characteristics and decreasing the emission of a diesel engine. The aluminium particles additive can be used to further improvement in the existing properties of Honge Oil Methyl Easter biodiesel (B20) fuel [7]. In addition carbon Nano tube additives to diesel found more beneficial, because it seems to produce high benefits like promoting thermal efficiency and decrease in emissions [8]. Analysis nano tubes of carbon with diesel shows carbon nano tubes having potential to use as an additive for diesel due to significant improvement in combustion and increase in NOx emissions. [5]. Nanoparticles blended to diesel increase the negligible density and viscosity, the significant thermal conductivity increases. The mixture was stable in blend for more than 2 months without remixing needed [10].

3. MATERIALS AND METHODS.

In the experimental research work Emissions and Performances test carried out in computerised 4 stroke single cylinder diesel fuelled, water cooled engine, specification of engine as mentioned in Table.2 Emissions are measured by gas analyser specification tabulated in Table.3, using Al_2O_3 Nanoparticles as additives at a different

proportion (50ppm, 100ppm and 150ppm) with optimized Biodiesel blend of Dairy scum (B20), performances like fuel consumption(FC), Thermal efficiency and Emissions were analysed at a 1500 rpm constant speed and obtained results are compared with the neat diesel fuel.

TABLE 1: PROPERTIES OF ALUMINIUM OXIDE PARTICLE

Particle Purity	99%
particle Average size	20-30nm
particle Color	White
Crystallographic structure of particle	Spherical
Melting point of particle	2040°C
Boiling point of particle	2977°C
Density of particle at 20^0 C	3.9 g/cm^3
Molar mass of particle	101.96g/mol
Molecular Weight of particle	101.96

3.1 Dairy scum Biodiesel

The diary scum is collected from the dairy milk waste products such as ghee and butter, the scum containing water impurities, it is heated at 55 to 60°C for moisture content removal. It will allow settle down solid wastes form that suspended particles are removed. Then oil will separated at the top layer and oil filtered. By transesterification process biodiesel was produced by various stages of processing with mixture of methanol and NaOH as Catalyst then oil, methanol and glycerin mixture, Separated scum methyl ester, by Washing of Bio Diesel and after Drying of Bio Diesel can be used in internal combustion engines.

Figure 1: Dairy scum waste and dairy scum oil

3.2 Aluminium oxide nanoparticle

Aluminium (Al_2O_3) Nano particles are used in different applications because of its beneficial enhanced properties, Addition of nanoparticles in fuels called as Nano fuels these can improve combustion in internal combustion engines and reduce emissions during combustion. Nano particles measure 1 to 100 nm size in diameter. Added Nano additives to biodiesel and diesel to enhance the fuel properties. Aluminium (Al_2O_3) Nano particles enhanced Biodiesel blend properties due to thermo properties of Nano particles, also reduces harmful emissions due to improve in combustion properties and reduce delay period etc.

3.2 Preparation of blends and Experimentation.

for the experimentation purpose Diesel, optimised dairy scum biodiesel B20 blend with Aluminium oxide nanoparticle of various proportions like 50ppm, 100ppm and 150ppm by ultrasonicator apparatus (Figure 2) for the duration of 30 minutes prepare homogeneous mixture of fuel blends.

Analyzer measures CO, HC, CO2 & NOx. Analyzers of gas working on the principle of light absorption by the gas under test. Absorption analyzers need shine a light beam through an sample chamber and measure specific wavelengths absorbed by the sample. The light absorption amount is

proportional to the concentration of the component in fluid which absorbed light.

Figure 2: Ultrasonicator

Figure 3: Computerised IC engine Test rig.

TABLE 2: ENGINE PARAMETERS

Parameters of Engine	**Engine Specification**
Diesel Engine	Four stroke single cylinder
Make	Kirloskar
No. of cylinders	1- Cylinder
Horse power of engine	5HP
Speed	1500 rpm
Bore(D)	80 mm
Stroke length(L)	110 mm
R_C -Compression ratio	17.5
Start of engine	Manual
Working cycles	four stroke
Cooling system	Water cooled system
Ignition system	Compression ignition system
Dynamometers	Eddy Current dynamometer

TABLE 3: SPECIFICATIONS OF GAS ANALYZER

Emission	**Range of Measuring**
CO	0.00% - 9.99%
HC	0ppm - 9999ppm
CO_2	0.00 - 20.0%
O_2	0.00 - 25.0%
NO_X	0ppm - 9999ppm

4. RESULTS AND DISCUSSION.

Experiments are conducted to find the properties of blends as per standards and results are tabulated in table 4. Results shows that variations of fuel properties.

TABLE 4: PROPERTIES OF BLENDS

Sl. No.	Properties	Units	Dairy scum	Diesel	DB20	DB20+ A50ppm	DB20+ A100ppm	DB20+ A150ppm
1	Density (at 15^OC)	Kg/m^3	890	840	845	847	848	850
2	Kinematic Viscosity (at 40^OC)	mm^2/s	3.8	4	3.89	3.91	3.92	3.94
3	Calorific value	kJ/kg	38750	42000	40950	41055	41128	41260
4	Cetane number	-	58	48	50	50	52	54
5	Flash point	^oC	158	50	69	68	66	63

Properties of Diesel, Dairy scum Biodiesel and Aluminium oxide Nano additives blends are tabulated in Table 4 After transesterification process density of dairy scum biodiesel is reduced but slightly higher than diesel. Viscosity plays a major role in fuel atomization, mixture formation of fuel air and combustion process. Dairy scum viscosity is very close to diesel fuel. Calorific value of fuel indicates the amount of energy content in the fuel and influences as determining the suitability of biodiesel as an engine fuel. The calorific values of dairy scum bio diesel blends found lower than that of diesel due to more oxygen content in biodiesel. The calorific values are increased with the nano additives of aluminium oxide due to their properties. Cetane number of biodiesel is more compare to diesel and it increases with increase in nano additives concentration. Flash point of dairy scum biodiesel is 27% more than diesel and decrease with increase in increases increase in concentration of aluminium oxide nano additives. DB20, DB20+A50ppm, DB20+A100ppm, DB20+A150ppm blend has 27.5%, 26.47%, 24.24% and 20.6% more flash point temperature compare to diesel fuel. Dairy scum, DB20, DB20+A50ppm, DB20+A100ppm, DB20+A150ppm has 7.7%, 2.5%, 2.25%, 2.07% and 1.76% less efficiency compare diesel fuel.

4.1 PERFORMANCE AND EMISSION PARAMETERS

A higher BSFC leads to lower efficiency. The properties such as density and heat content of the fuel has a directly influence on the BSFC, It can be observed that the BSFC is higher for Dairy scum B20 compare to diesel full load conditions 38%, 28%, 22%, 18% of more fuel consumed in DB20, DB20+A50ppm, DB20+A100ppm, DB20+A150ppm respectively when compared to diesel and 29%, 20%, 16% of more fuel consumed in DB20+F50ppm, DB20+F100ppm, DB20+F150ppm blends.

From experimental result it has been is observed that dairy scum B20 blend has 27% less brake thermal efficiency compare to diesel, 26%, 22%, 15% less efficiency DB20+A50ppm, DB20+A100ppm, DB20+A150ppm respectively as shown in figure 5.

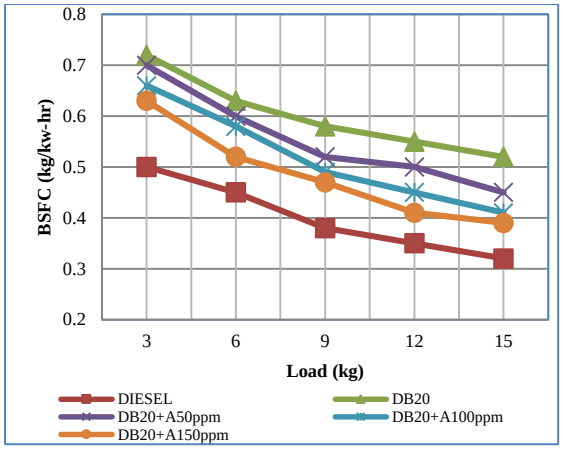

Figure 4: (BSFC) -Brake specific fuel consumption

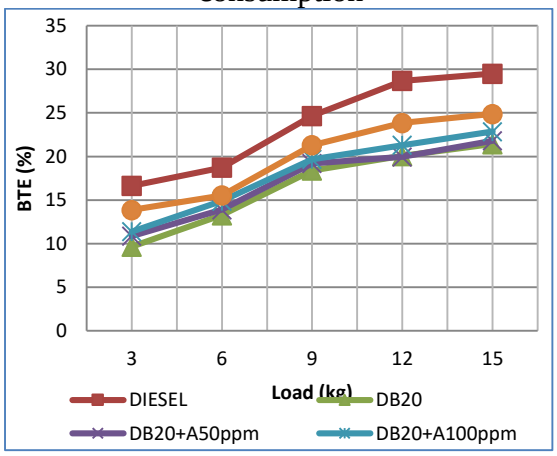

Figure 5: (BTE) -Brake thermal efficiency

Hydrocarbon emissions of all the blends were lower compare to diesel, but increases with load. From results it seen that DB20+A150ppm blend shows less emission and 13%, 20%, 23% and 30% less emission observed in DB20, DB20+A50ppm, DB20+A100ppm, DB20+A150ppm respectively as shown in Figure 6.

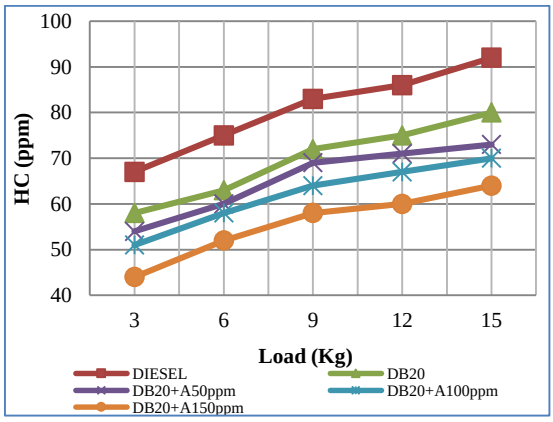

Figure 6: (HC) -Hydrocarbon Emissions

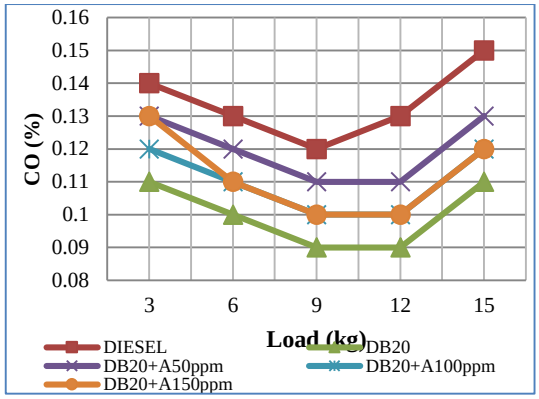

Figure 7: (CO) -Carbon Monoxide Emissions

Results shows that maximum CO emission in diesel compare to other blends and 26%, 15%, 20%, 20% emissions was reduced in DB20, DB20+A50ppm, DB20+A100ppm, DB20+A150ppm blends respectively, 20%, 13%, 6%, 6% emissions was reduced in DB20 as shown in Figure 7.

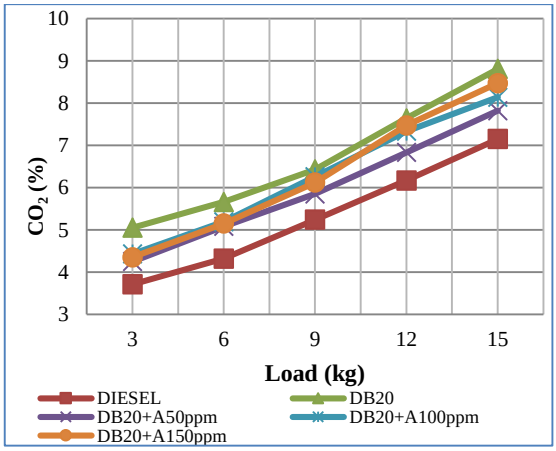

Figure 8: (CO_2) -Carbon Dioxide Emissions

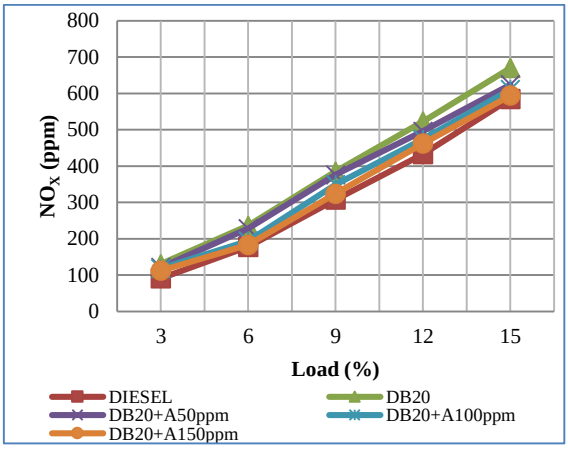

Figure 9: (NO_X) -Nitrogen Oxide Emissions

Compared to conventional diesel DB20 shows 18.84% higher carbon dioxide emission compare to other blends. DB20+F50ppm blend shows 8.56% more emission compare to diesel and lesser emission among all blends. DB20, DB20+A50ppm, DB20+A100ppm, DB20+A150ppm blends has 18.8%, 8.5%, 12.1% and 15.5% more carbon dioxide emission was observed as shown in figure 8.

Results shows that maximum NOx emission in biodiesel due to high oxygen content compare to diesel 12%, 6%, 4% and 1% higher emissions was observed in dairy scum with aluminium oxide Nano additives DB20, DB20+A50ppm, DB20+A100ppm, DB20+A150ppm blends respectively as shown in figure 9.

Biodiesel blend (DB20) peak pressure is less compare to diesel due to lower calorific value and 5%, 4.3%, 1.3% and 1.8% lower peak pressure was recorded in DB20, DB20+A50ppm, DB20+A100ppm, DB20+A150ppm blends respectively, reason for increase in peak pressure with additives is nano particles are having higher surface area to increase their chemical reaction and it reduces the ignition delay.

A higher exhaust gas temperature indicates lower fuel energy utilization in the engine and exhaust gas temperature respect to with load are shown in Figure number 11 .At maximum load condition, the exhaust gas temperature for Diesel,DB20, DB20+A50ppm, DB20+A100ppm, DB20+A150ppm blends are 424°C 438°C,432°C, 430°C and 428°C respectively

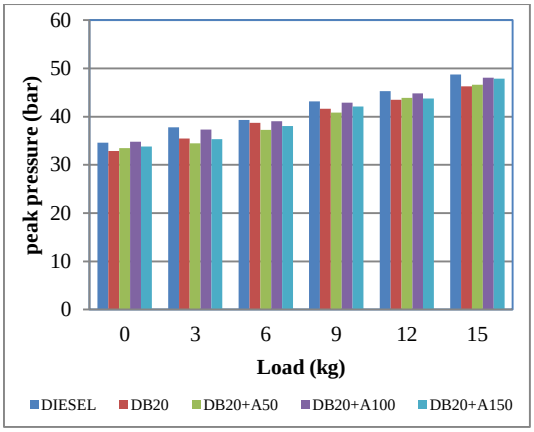

Figure 9: peak pressure

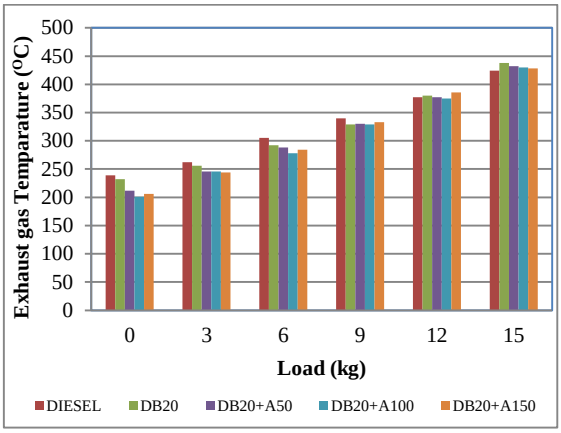

Figure 9: exhaust gas temperature

5. CONCLUSIONS

emission and combustion characteristics of Dairy scum Biodiesel with Aluminium oxide Nano additive blends of 50ppm, 100ppm and 150ppm proportions respectively, from experimental result following conclusions are drawn.

- Heating value of fuel blends are raises with increase in concentration of aluminium oxide Nano additives DB20 shows 40950 kj/kg and DB20+A150ppm 41260 kj/kg of calorific value 310 kj/kg increases with additives.Flash point and cetane number of blends are reduces with increase in concentration of additives; flash point of DB20 16oC more compare to pure diesel, DB20+A150ppm shows 6 oC less.
- Brake specific fuel consumption is higher in DB20 38% higher fuel consumed compare to diesel, at full load conditions 18% of more fuel

consumed in DB20+A150ppm compared to diesel. Brake thermal efficiency dairy scum B20 blend has 27% less compare to diesel, 15% less efficiency in DB20+A150ppm blend.

- Hydrocarbon emissions of all the blends are lower compare to diesel, but increases with load. From results it seen that DB20+A150ppm blend shows 30% less emission. Carbon Monoxide (CO) emission in diesel compare to other blends and 26% emissions was reduced in DB20, DB20+A150ppm shows 6% less emissions compare to diesel, as increase in in additive concentration emissions was decreases. Nitrogen Oxide (NOx) emission in DB20 shows 12% higher and DB20+A150ppm.
- Peak pressure of DB20 shows 5% less, DB20+A100ppm shows 1.3% less, Exhaust gas temperature for Diesel was 424°C, less exhaust temperature was recorded in DB20+A150ppm blends are 428°C.

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