Effects of Al_2O_3 Nano Additives on the Performance and Emission of Dairy Scum Biodiesel Blended Diesel Engine

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ABSTRACT

The Diesel engine is one of the most efficient engines among all types of internal combustion engines. Conventional fossil fuels cause more pollution this leads to search for environmentally friendly and renewable fuels.

Biodiesel is one of the alternative source of fuels Biodiesel contains virtually no Sulphur or aromatics and use of biodiesel in a conventional Diesel engine result in substantial reduction of unburned hydrocarbons, carbon monoxide and particulate matter but disadvantages of biodiesel are higher density, lesser heating value, high fuel consumption and high oxides of nitrogen emission. To overcome this draw back additives are used with biodiesel. Due to their special properties like higher thermal conductivity, chemical properties additives promote better combustion this causes reduction of hydrocarbon emission and improve the performance of CI engine.

In the present experimental work planned to carryout performance and emission tests of Al_2O_3 Nanoparticles additives of different proportion (50ppm, 100ppm and 150ppm) with optimized Dairy scum Biodiesel blend (B20).

From this study, it is perceived that the addition of AL_2O_3 nano additive with Dairy scum Biodiesel-B20 enhance the brake thermal efficiency and marginally lower the brake-specific fuel consumption (BSFC) and HC, CO emissions and Marginal Increases in NO_X. This study also revealed that B20+150 ppm nano additive fuel blend has exhibited the better performance, combustion and emission parameters.

Keywords: Biodiesel, Additives, Performance, Combustion, Emissions.

INTRODUCTION

Fossil fuels are biological materials containing hydrocarbon, which can be burned and used as a source of energy. Fossil fuels found in the Earth's crust, Global carbon emissions from fossil fuels accounts for 90% of all emissions from human activity. The literatures reviewed shows a reduction in exhaust emissions such as unburned hydrocarbons (UBHC), carbon monoxide (CO) and particulate matters (PM) with the inclusion of metallic and oxygenated additives in the diesel-biodiesel blends due to enhanced ignition characteristics, higher oxygen content and presence of lower aromatic compounds.

Efficient use of natural resources is one of the fundamental requirements for any country to become self-sustainable with the fossil fuel depleting very fast, researchers have concentrated on developing new agro based alternative fuels, which will provide sustainable solution to the energy crises.

The world demand for energy is rapidly increasing. We need energy to cook our meals, to travel and communicate, and to power our factories. The amount of energy available to us determines not only our standard of living, but also how long we live. One of the main energy sources is oil and rate of production is expected to peak in the next few years. There are still plentiful supplies of coal, the other principal energy source, but it is even more because to meet our requirement. Biodiesel is a biodegradable, clean- burning combustible fuel derived fuel from new or used vegetable oils or animal fats. Biodiesel meets American society for testing and materials (ASTM) specifications and is a registered fuel and fuel additive by the U.S environmental agency. Biodiesel can be used in any internal combustion diesel engine in either its pure form, which is referred to as neat biodiesel, or it can be mixed in any concentration with regular petroleum dies.

DAIRY SCUM BIODIESEL

Dairy waste scum is generated by dairy industries which handle raw and chilled milk and milk products like butter, ghee, cheese, yoghurt, ice creams etc., A large dairy, which processes 5 lakh litre of milk per day generates 250–300 kg of effluent scum per day, which makes it difficult to dispose (Holland and Redfern, 1997). Dairy scum is a less dense, floating solid mass formed by the mixture of fats, lipids, proteins etc., which creates difficulties in handling and operations in effluent treatment plants. Since these scum materials contains a large amount of triglycerides and is therefore selected as a feedstock in the present study.

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The main objective of the present study is to provide an economically feasible and viable technology to produce biodiesel at low cost using waste materials as feedstock and catalyst.

The efficacy of the CaO derived from eggshell is studied towards the transesterification of dairy scum. The effect of reaction parameters like catalyst loading, temperature, reaction time and methanol amount on the yield of fatty acids methyl esters (FAME) was assessed. The physicochemical characteristics of the produced biodiesel were determined and the performance of the scum biodiesel along with its emission characteristics were compared with conventional diesel. Thus, utilization of CaO as a heterogeneous catalyst from eggshell waste in the conversion of dairy waste scum to biodiesel, can improve sustainability through the generation of value-added product.

ALUMINIUM OXIDE NANOPARTICLE

Aluminum Oxide nanoparticle (Al_2O_3) has been used in different applications because of its various importance and beneficial properties. The chemical compound of alumina composed of aluminum and oxygen and most widely used ceramic materials among others ceramic material such as aluminum nitride, zirconia, silicon carbide, etc. Various applications that used alumina are as a biomedical implant, catalyst support and absorbents, fire retardants, polymer matrix composite, insulator and in clinical field, electronic fields, etc. The reason of alumina most widely attractive used material in many applications is due to its greater properties such as chemical and thermal stability, relatively good strength, good wear resistance, high hardness, high melting points, and good electrical and chemical resistance. Alumina can be synthesized into different phases including alpha, beta, gamma, and delta. All of these phases can be attained at different temperature during synthesizing of alumina. Each phase have its own features which are different for application used. However, among these phases the alpha alumina is most stable structure and popular among researchers due to its superior properties such as high hardness, high stability, high insulation and transparency.

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EXPERIMENTATION

Preparation of Blends

In the first step of study, 20% dairy scum biodiesel is considered as fuel and aluminum oxide (Al_2O_3) is considered as the nano-additive to evaluate the engine performance. In second step engine modifies with optimized engine parameters. Finally, in third step experimental results of (performance, combustion and emission characteristics) the both modified fuel and engine are compared with the existing baseline engine. The work matrix of the present study is presented in Table 1.

Table no.1.**0** Work matrix

Fuel and Nano-additive Selection	Engine Modifications	Experimental Investigation Parameters
Step-1: 1) Dairy scum biodiesel (B20) 2) Aluminum oxide (Al_2O_3)	**Step-2:** 1) IOP: 230 bar 2) IT: 29° bTDC 3) CR: 18 4) Nozzle: 5 holes 5) Piston: RTPBG	**Step-3:** 1) Performance 2) Combustion 3) Emission

In the current study,50 ppm,100 ppm,150 ppm of Al_2O_3 nanoparticles particles are added to one liter of 20% diary scum biodiesel and nano particles are dispersed well with biodiesel blend using ultrasonicator and mechanical stirrer. To control the sedimentation of nano particles CTAB (Cetyl Trimethyl Ammonium Bromide) surfactant is employed to provide the negative charge to the particles to thus sedimentation of particle is avoided. To avoid the sedimentation of the nano particles, the fuel blends are shaken well before conducting the experimentation. The schematic view of the nano additive fuel blend preparation and utilization is demonstrated in Figure 1.

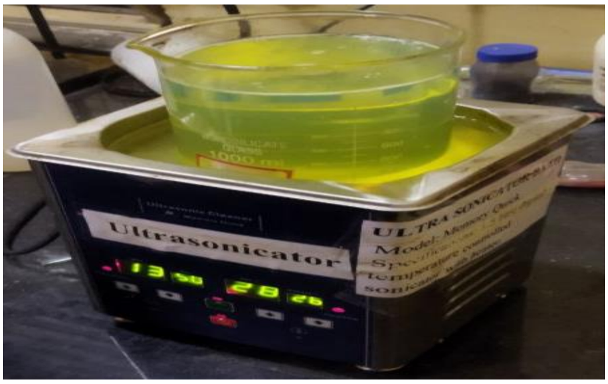


Fig no.1.0 Ultrasonicator

COMPUTERAISED IC ENGINE

The schematic and pictorial view of the experimental setup is depicted in Figure. The tests were conducted on Kirloskar (TV1) 4 stroke, VCR (variable compression ratio) diesel engine of 3.5 kW power. Eddy current dynamometer with load cell is used to vary the loads in steps of 20, 40, 60, 80 and 100%. Engine is operated at constant speed of 1500 rpm throughout the experiments. The detailed technical specifications of the engine are given. The various flow meters are used to measure the fuel flow rate, water flow arte and air flow rate. The K type thermocouples are used to determine the various temperatures in the engine. The combustion parameters like P-θ, HRR, CHRR, ID, CD and PRR are evaluated with the help of "Engine soft LV" software with Piezo sensor and crank angle sensors. Airrex Automotive Emission Analyzer HG-540) was used to determine the exhaust emissions (HC, CO, and NOx).

Fig no. 1.2. Schematic view of the engine test setup.

Schematic view of the engine test set-up. (1) Engine, (2) dynamometer, (3) encoder, (4) control panel, (5) exhaust gas analyzer, (6) fuel burette, (7) diesel tank, (8) biodiesel tank, (9) temperature signals and (10) data acquisition system.

Engine specifications

Tabel no : 1.2 Computerized 4 stroke Diesel Engine Specification

Engine	Vertical 4stroke Diesel Engine
Make	Kirloskar Make
Number of cylinders	01
Rated Output	5HP
Engine speed	1500RPM
Bore diameter	80mm
Length of the Stroke	110mm
Compression Ratio	17.5:1
Dynamometer	Eddy Current Type (Power mag Make)
Excitation Voltage	0-90 Volts (No Load)
Excitation Current	3.5 Amps (Maximum)
Load Voltage	45 Volts (Maximum)
Load Current	3.5 Amps (Maximum)

Emission Testing

The gas analyzer meant for monitoring CO, CO_2, HC, O_2 and NO_x in automotive exhaust. O_2 and NO_x by electrochemical sensors. It is also supplied as a five-gas analyzer which can be upgraded easily to gas version by the addition of an NO_x sensor. It has many control features to prevent faulty measurements. A built-in dot-matrix printer is provided to print out a hard copy of the results. This analyzer is an equipment to measure the gas emission density of an automobile enabling to diagnose. The automobile status and its preventive maintenance so that it can provide a function to prevent the air pollution in advance. A built-in dot-matrix printer is provided to print out a hard copy of the results. This analyzer is an equipment to measure the gas emission density of an automobile enabling to diagnose.

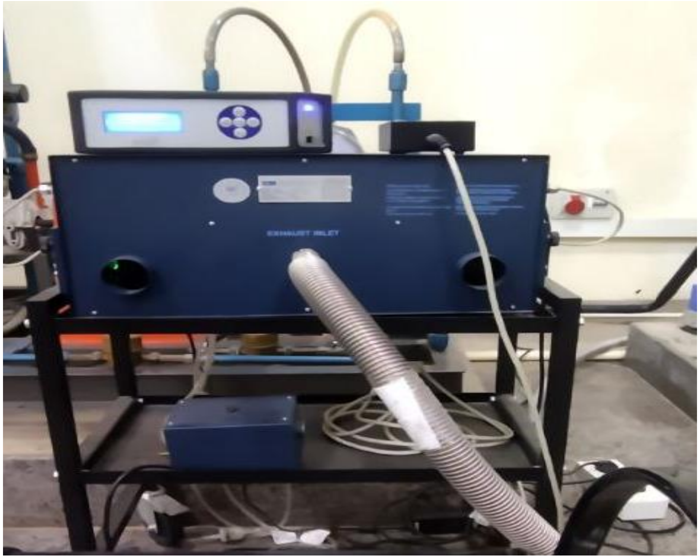


Fig no.1.3 Emission Testing Machine

SPECIFICATION

1. Measuring Items: CO, HC, CO_2, O_2, NO_x

2. Measuring Range:CO: 0.00% - 9.99%

   HC: 0ppm - 9999ppm

   CO_2: 0.0 - 20.0%

   O_2 : 0.0 - 25.0%

   NO_X : 0ppm - 9999ppm

3. Power Consumption: Approx. 50W

4. Optional accessories: Printer

Experimental test set-up

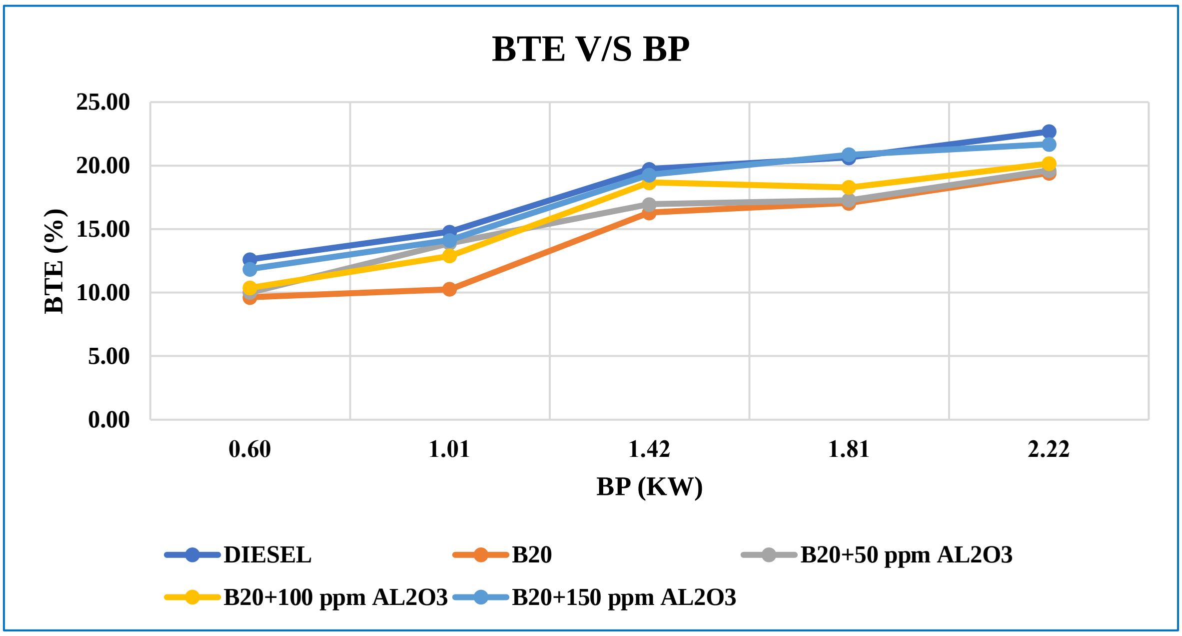
The schematic view of the experimental set-up is depicted in Figure .1 The tests were conducted on Kirloskar (TV1) 4 stroke, VCR (variable compression ratio) diesel engine of 3.5 kW power. An Eddy current dynamometer with a load cell is used to vary the loads in steps of 20%, 40%, 60%, 80% and 100%. The engine is operated at a constant speed of 1500 rpm throughout the experiments. The detailed technical specifications of the engine are given in Table .1.1 The various flow meters are used to measure the fuel flow rate, water flow rate and air flow rate. The K-type thermocouples are used to determine the various temperatures in the engine. The combustion parameters, like P-θ, HRR, CHRR, ID, CD and PRR, are evaluated with the help of 'Engine soft LV' software with a Piezo sensor and crank angle sensors. An Airrex Automotive Emission Analyser HG-540 (specification of the gas analyser is shown.) was used to determine the exhaust emissions (HC, CO and NOx).

RESULTS & DISCUSSIONS

Table 1.3 Tabulation of properties of Diesel, Biodiesel and its blends

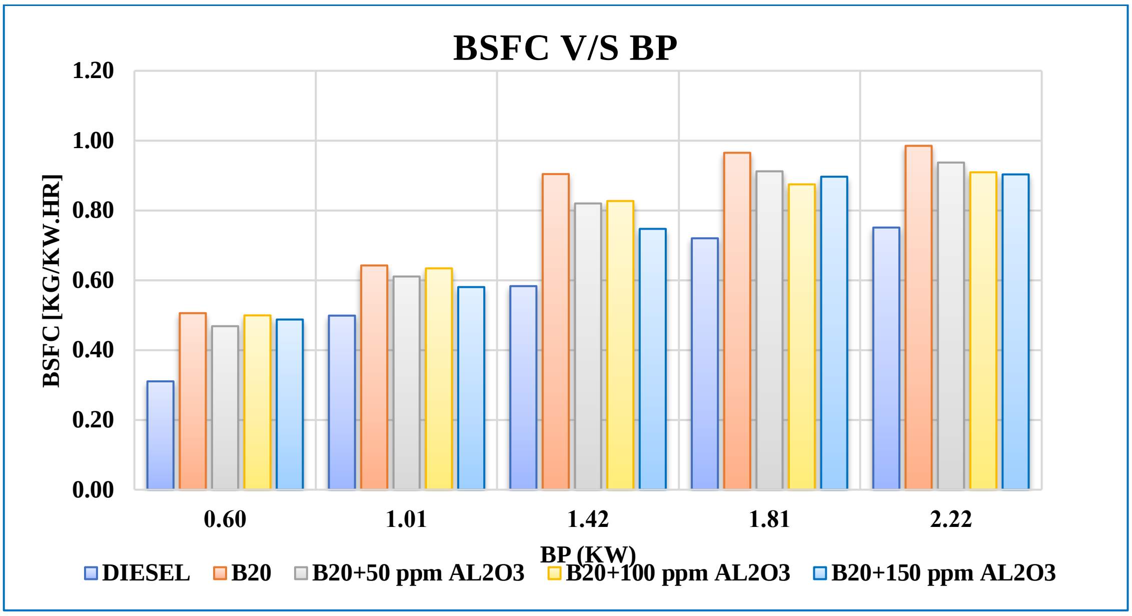
Fuel	Diesel	B20	50ppm	100ppm	150ppm
Density (kg/m^3)	830	840	841	841	842
Kinematic Viscosity (Cst)	2.9	2.98	2.98	2.98	2.99
Calorific Value (MJ/kg)	43	40.89	41.02	41.50	42.45
Flash Point (^oC)	50	60	58	56	55
Fire Point (^oC)	55	65	62	60	58

BRAKE THERMAL EFFICIENCY (BTE)



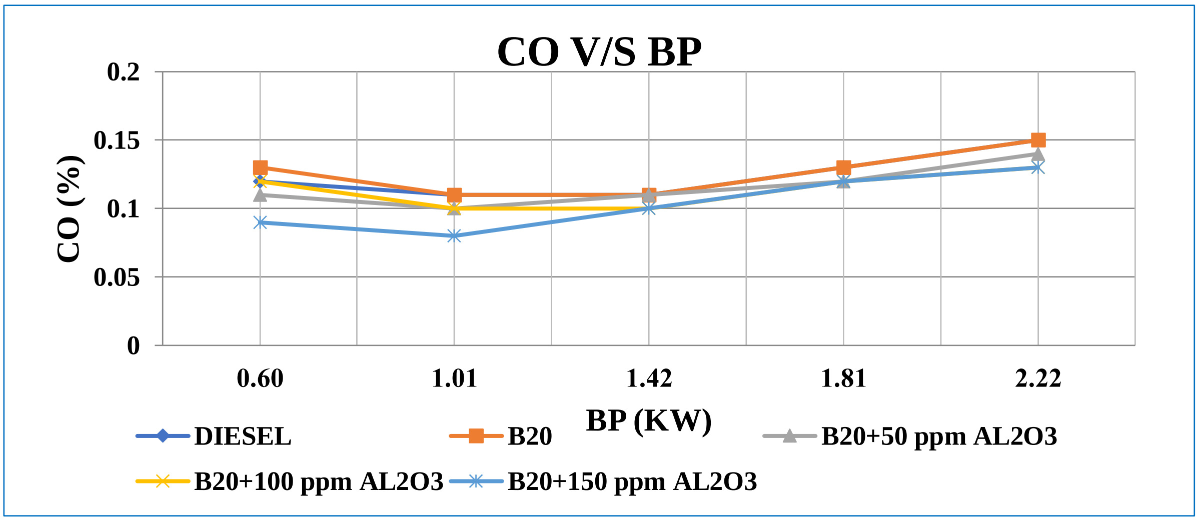
Above chart shows Maximum Break Thermal Efficiency is obtained in the Diesel engine and B20+150ppm Al_2O_3 shows almost near efficiency to the diesel. Biodiesel shows less efficiency compared to the other blends. Biodiesel shows 19.62% and B20+150ppm Al_2O_3 shows 21.69% comparatively 10.41% of Break thermal efficiency is Increased. and compared with Diesel 4.36% of Break thermal efficiency is Increased.

BREAK SPECIFIC FUEL CONSUMPTION (BSFC)



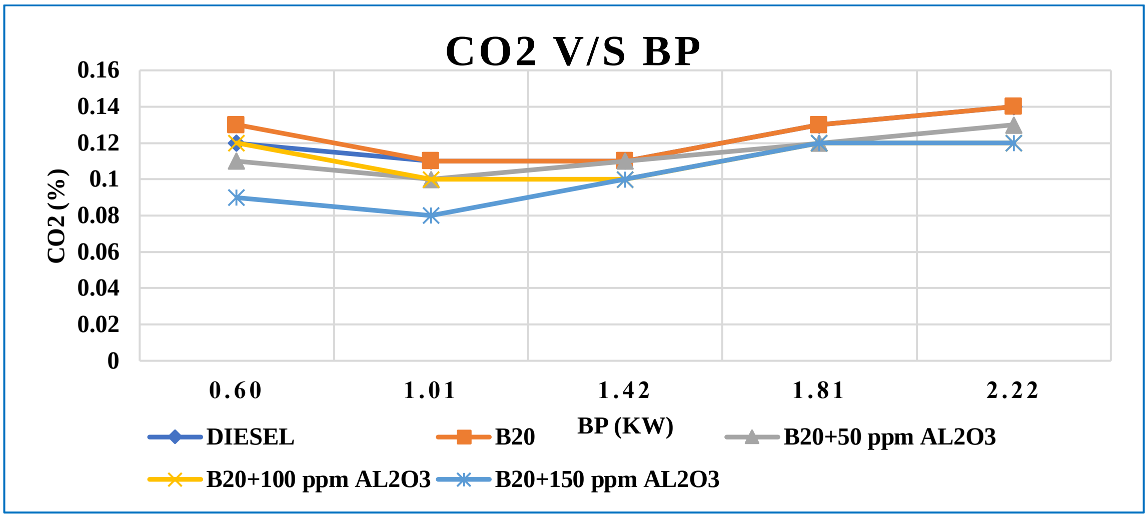
Above chart shows Maximum Break specific fuel consumption is obtained in the Diesel engine. and B20+150ppm Al_2O_3 shows more fuel consumption to the diesel. Biodiesel shows less efficiency compared to the other blends. Biodiesel shows 0.99% and B20+150ppm Al_2O_3 shows 0.90% comparatively 9.09% of Break specific fuel consumption is Increased. and compared with Diesel 15% of Break specific fuel consumption is decreased.

CARBON MANOXIDE (CO)



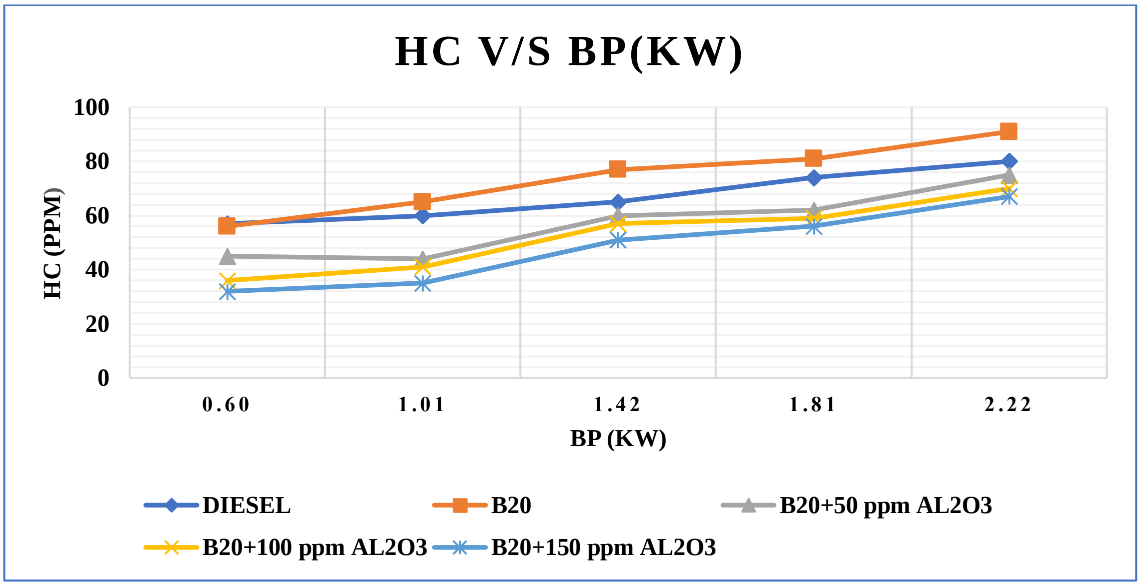
Above chart shows Carbon monoxide Emission of various blends, B20+150ppm Aluminum oxide Nano particle blend shows lesser emissions among all the blends. and Diesel shows more emission. Diesel and Biodiesel shows 13.33% more carbon monoxide emission compared to B20+150ppm Aluminum oxide Nano particle blend.

CARBON DIOXIDE (CO_2)



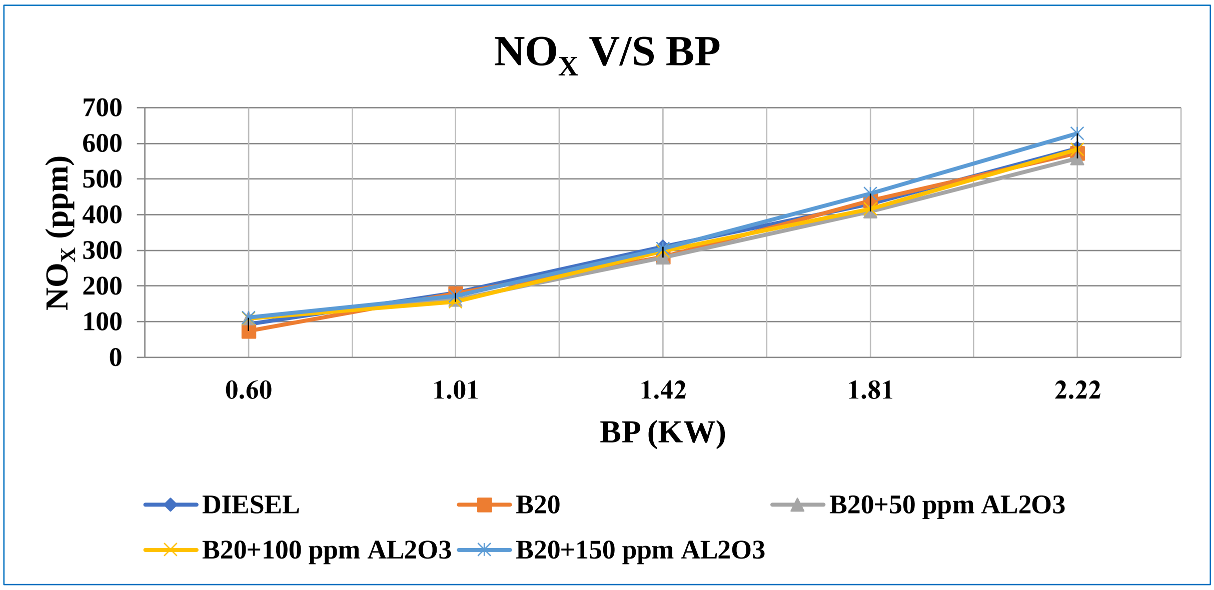
Above chart shows Carbon dioxide Emission of various blends, B20+150ppm Aluminum oxide Nano particle blend shows less emissions among all the blends. And Diesel shows more emission. Diesel and Biodiesel shows 14.28% more carbon monoxide emission compared to B20+150ppm Aluminum oxide Nano particle blend.

HYDRO CARBON (HC)



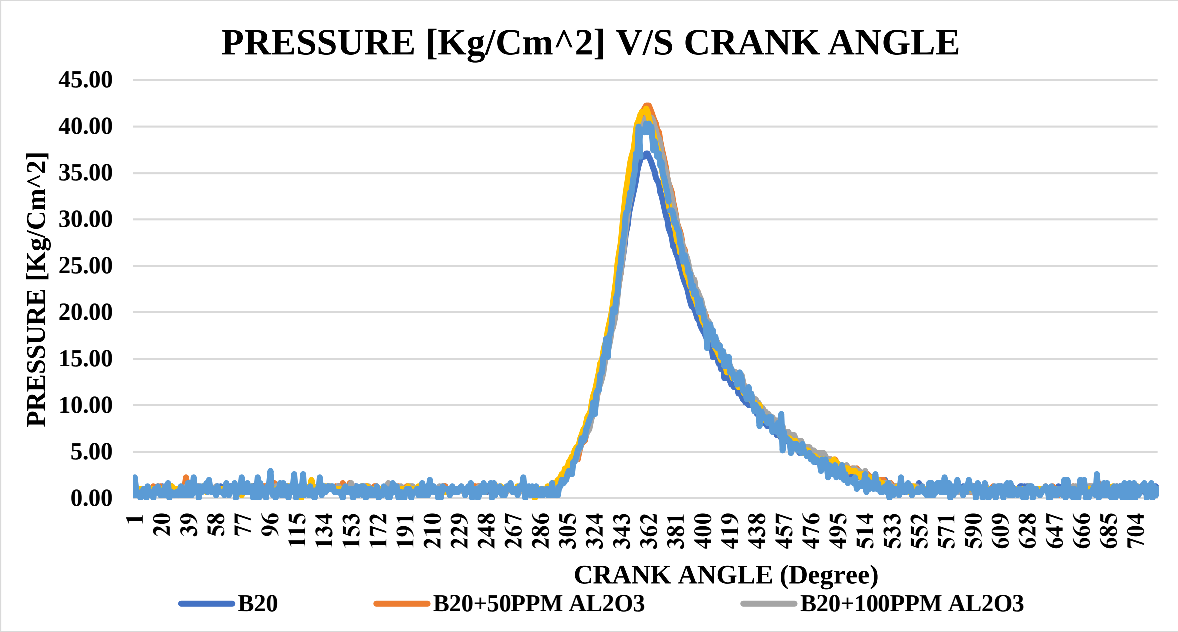
Above chart shows Hydro carbon Emission of various blends, B20+150ppm Aluminum oxide Nano particle blend shows less emissions among all the blends. and Diesel shows 16.25% more Hydro carbon and Biodiesel shows 26.37% more Hydro carbon emission compared to B20+150ppm Aluminum oxide Nano particle blend.

NITROGEN OXIDE (NO_x)



Above chart shows Nitrogen oxide is obtained in the Diesel engine and B20+150ppm Al_2O_3 shows almost more emission to the diesel. Biodiesel shows less emission compared to the other blends. Biodiesel shows 573ppm and B20+150ppm Al_2O_3 shows 628ppm comparatively 8.75% of Nitrogen oxide emission is Increased. and compared to diesel 6.68% of Nitrogen oxide is Increased.

Variation of Pressure V/S Crank angle



Maximum Pressure obtained In Diesel and as Nano particle added Pressure Increased compared to Dairy scum Bio diesel. At B20+150ppm Al_2O_3 shows nearer Pressure compare to Diesel.

CONCLUSIONS

The performance and emission characteristics of a CI engine with diesel, Dairy scum biodiesel blends and Aluminium oxide nanoparticles as additive were investigated. The following conclusions were made from the experimental results.

- At full load, the Dairy Scum-B20 + AL2O3-150ppm fuel blend has shown the 4.36% of increased BTE and 9.09% of lowered BSFC when compared to the sole Dairy scum-B20 fuel blend.
- At 100% load, the Dairyscum-B20 + AL2O3 fuel blend has resulted the 8.75% of increased NO_x.
- At maximum load, Dairy scum-B20 + AL2O3-150ppm fuel blend has revealed the 26.37% of lowered HC, 13.35% of lowered CO,14.28% of lowered CO_2 when compared to the Dairy scum-B20.

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