Theoretical analysis on ci engine by multiple injection pressure with alternative fuel by adding aluminum oxide as nano additive

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ABSTRACT

Diesel fuel vehicles discharges considerable number of pollutants like CO, UHC, NOX, soot which are very harmful to environment and society. However, to overcome this menace, the biofuels are being used in IC engines as alternative fuels. To attain the complete combustion of the charge in the cylinder the fuel injection parameters play a wide role. The major parameters are no. of fuel nozzle holes, fuel droplet size and fuel injection pressure. These parameters can influence the performance of engine as well as emission characteristics of an IC engine. In this present work, experimental analysis to be carried out using alternative fuel with additive in a single cylinder, 4stroke water cooled light duty injection CI engine at various injection pressures 185, 195 and 210 bars. Here, we use lemongrass oils alternative fuel with aluminum oxide as nano additive

Keywords: *LemonGrass, Biodiesel, NO_x mitigation, Antioxidant additives, aluminum oxide Nanoparticles Emissions, Diesel Engine*

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1. INTRODUCTION

The world energy requirement in the automobile industry is majorly meet out by conventional petroleum derivatives. However, the usage of such petroleum products creates an adverse environ mental effect. The biodiesel synthesized from edible or non-edible vegetable oil is one such alternative to address partially the undesirable environmental effect caused by diesel. Almost three-fourth of the biodiesel synthesis cost is responsible for its base vegetable oil. In this perspective, biodiesel formulated from cost-effective waste feedstock such as waste cooking oil, waste plastic oil, waste transformer oil, waste ayurvedic oil and waste fish oil has paid greater interest in recent years. The feedstock from the waste resource is attractive not only due to cheaper raw materials; also, it reduces the cost of disposal/solid-waste management system. Today diesel engines are a lot cleaner and proficient than the past adaptations, half way on the grounds that they run on an extensively characterized diesel fuel. This makes the motor makes to tune the diesel fuel framework for improved proficiency. Biodiesel and Diesel fuel are closely resembling in their synthetic and physical qualities they have very similar characteristics so that it is suitable to use in diesel engine. Vegetable oil is three long molecules of hydro carbons bounded with a methyl radical called glycerin.

The compound cycle trade out the glycerin particle with three methanol radicals. Since the response is reversible, we utilize an over abundance of methanol to drive the response towards the development of methylesters. Not with standing its less expense of the veatable oils, another in contestable improvement of non-eatable oils for biodiesel creation lies in the way that no palatable oils are expended to deliver biodiesel fuel for use in compression ignition Engine. India ranks 6th in terms of consumption of energy i.e. 3.5% of the total world's commercial energy. The current consumption of diesel in India is about 40 million tons (MT) (40% of the total consumption of petroleum in the country) and is expected to reach 65 million tonnes (MT) by 2011-12, whereas the domestic production of crude oil and natural gas will be less as compared to demand. There is huge gap between demand and supplywhich is presently metby imports putting heavy burden of foreign exchange on the country. Production of biodiesel from oil and ethanol from sugar based resources are considered as the best substitute of diesel and gasoline respectively in the country. The waste and degraded land after reclamation can be used to grow the resource, produce oil and its conversion to biodiesel.

At present, India is producing only 30% of the total petroleum fuels required. The remaining 70% is being imported, which costs about Rs.80,000 crore every year. It is an astonishing fact that mixing of 5% bio-diesel fuel to the present diesel fuel is made available in our country, which can save about Rs. 4000 crore every year. It is estimated that India will be able to produce 288 metric tonnes of biodiesel by the end of 2012, which will supplement 41.14% of the total demand of diesel fuel consumption inIndia.The planning commission of India has launched a bio-fuel project in 200 districts from 18 states in India. It has recommended two plant species, viz. jatropha (Jatropha curcas) and karanja (Pungamia pinnata) for bio-diesel production [2–17]. The recent auto fuel policy document states that biofuels are efficient, eco-friendly and 100% natural energy alternative to petroleum fuels.

The life cycle for production of biodiesel begins with the abstraction of all raw materials to make petroleum diesel and biodiesel, and end with using the fuels for running of vehicles and industrial needs. The below indicated figure represents complete life cycle involved in the production of biodiese
l. The production process involves starting with the harvesting of seeds from the feedstock/livestock and there by extracting oil by using mechanical methods such as crusher and followed by trans-esterification of oil. After this process the obtained oil is blended 3 with diesel suchas B20 (20% Biodiesel+80% Diesel), B30 (30% Biodiesel+70% Diesel), B40 (40% Biodiesel+60%Diesel) is allowed for testing followed by usage in the vehicles and industrial needs.Methyl ester of karanja oil as an alternative renewable source energy by P.kSrivastava and Madhumitaverma investigated on karanja oil blends B10, B20, B30 and resulted that brake specific fuel consumption,exhaust gas temperature, HC, CO, NOx are higher when compared to diesel. But all the physical and chemical properties are quite close to that of diesel. Experiment al investigation on performance, combustion and emission analysis of a direct injection diesel engine fueled with rapeseed oil biodiesel by L.AnanthaRaman, S.Rajakumar reported that by using Rape seed oil brake specific fuel consumpti on, exhaust gas temperature, smoke, NOx of the engine increase by using different blends whereas CO, HC, Brake thermal efficiency lowers than diesel fuel.

Combustion performance and emission characteristics study of pine oil in a diesel engine by Rvallinayagam, W.M.Yang reported that pine oil can be directly used in diesel engines without transesterification due to its unique properties. Pine oil shows better thermal efficiency and specific fuel consumption than diesel. At maximum load conditions exhaust emissions like HC, CO, smoke have been reduced by 65%, 30%, 70% but NOx emits 25% higher than diesel. Prediction of exhaust gas emission characteristics using neem oil blended biodiesel in diesel engine by V. Velmurugan has conducted his experiment on Neem oil having high fatty acids which takes two step transesterification process, reported that B20 has the least NOx emission (24.6%) when compared to pure diesel (30.6%).brake thermal efficiency for B20 is about 30.29% higher than pure diesel.

Emission and performance analysis of hydro treated refined sunflower oil as alternative fuel by JHemanandh, K.V.Narayana reported by using hydrotreated refined sunflower oil B30 that CO, 11 HC, NOx, brake specific fuel consumption decreases by 9%, 42%, 10%, 25% when compared with B100 but increase in thermal efficiency by 10% compared with B100. Performance and emission characteristics of rice bran oil by Shailendra Sinhaetal has investigated the performance and combustion characteristics using rice bran oil and reported that lower blends of rice bran oil increase performance, lowers emissions. Where as higher blends increase emissions and decrease performance.

Fig: 1.Lemon grass after harvest

II. MATERIALSANDMETHODSOFPRODUCTION

In considering the issue of direct utilization of crude Lemon grass oil and continuous intermittent upgrading of motor, it is advantageous to utilize change strategies that help to diminish the consistency of oil the item appropriate as engine fuel. Many normalized systems are accessible for the alteration ofcrude Lemon grass oil. The ordinarily utilized techniques are examined in the accompanying areas. Trans-esterification is the most widely recognized strategy for changing over oil into biodiesel that can be utilized legitimately or as mixes with diesel in diesel engine. It is additionally called alcoholics, is displacing of alcohol from an ester by another alcohol in a cycle like hydrolysis, then again, actually alcohol is utilized rather than water. This cycle has been generally used to diminish the thickness offatty substances. A catalyst is normally used 15 to accelerate the response that might be acidic, basic, corrosive or enzymatic in nature. The entire trans-esterification can be divided in to three stages. Trans-esterification is a strategy for hanging of an ester into another when a vegetable oil is responded with methanolin the presence of catalyst to give methylester which tends to form biodiesel and glycerin.

Fig:2. Extraction and trans-esterification of Lemon grass oil

In this work the acquired crude Lemon grass oil which is separated from the seeds contains high viscosity, and less unpredictable and it has low atomization properties so to do that we convert fatty oil to methyl ester. In the example readiness of biodiesel, one liter of Lemon grass oil is heated in a magnetic stirrer apparatus, containing a hot plate and stirrer. The oil is warmed up to 65^{o}C and in equal, KOH (potassium hydroxide) pallets were disintegrated with methanol in a different vessel which tends the reaction towards the formation of potassium meth oxide. The shaped potassium meth oxide solution is then poured in the warmed oil. At first the oil is taken in to attractive stirrer device the Lemon Grass oil is made to warm at temperature at 65^{o}C. A measuring glass is taken with a methanol and KOH beds mixed it well so 17 both blends and structure potassium meth oxide solution. This potassium methoxide is poured in to the attractive stirrer contraption containing oil and mixed well, which will in general structure Lemon Grass Oil Methyl Ester(LGOME) and glycerol. The acquired blend is permitted to settle for about 3hrs with the goal that glycerine gets isolated from methyl ester. Lemon Grass methyl ester is isolated and heated water is passed in to it, and washed so glycerine gets isolated as white fluid. The obtained produce Lemon Grass oil methylesteris under gone subsequent 16 washing with hot water to certain temperature to eliminate leftover waste and limited quantity of water fumes present in it.

2.1. ALUMINUM OXIDE (AL_2O_3) NANOPARTICLES

Nanoparticles and miniature particles of aluminum have likewise been researched as an expected fuel added substance. Aluminum is known to build the force yield of motors, because of its high burning vitality. Recent developments of nanoparticles have made the atoms of the fuel to increase surface to volume ratio, reduced atomic particle size and structure into fine droplets. There by increasing the performance of the engine. An investigation did by a group of scientists discovered that nano sized particles of aluminum gave a more worthy performance than micro particles. The characteristics are improved by increasing the chemical properties during combustion, which makes the air fuel mixing better and cleaner, efficient combustion, Enhance rapid evaporation. Also, the nano particles scattering in ethanol based fuels were obviously superior to those in typical hydrocarbons, Aluminum oxide shows better outcomes for the same type of oils. The amount of oxygen available in aluminum oxide is 47.04%.

Fig:3. Aluminum oxide Nano particles

The properties of crude Lemon grass oil was estimated and compared with the diesel it is seen that the viscosity of crude Lemon grass oil is far more greater than that of diesel which isn't appropriate to use in diesel engine without adjustment, which may bring about issues, for example, atomization, sticking of unburnt hydrocarbons so as to make the crude oil to make use in the engine with out alteration is by tran-sesterification. Transesterification is the way toward decreasing the viscosity and density which is ideal for the utilization as biodiesel in internal combustion engine. The properties of Lemon grass oil methyl ester and its blends are estimated. It is seen that the calorific value of Lemon grass oil methylester is near that of diesel and the cetane number is more prominent than that of diesel.

III. EXPERMENTAL SETUP AND ARRANGEMENT

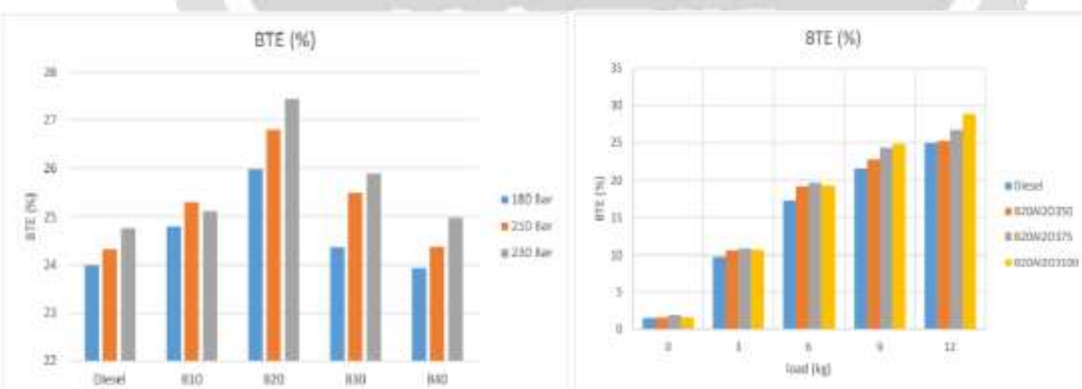
The schematic layout of a single-cylinder, direct injection, a four-stroke diesel engine is shown in Fig. 4. The technical specifications of the test engine are listed in Table 5. A hydraulic dynamometer was coupled to the test engine for engine loading. A speed sensor and an airflow sensor were used to measure the engine speed and air intake respectively. The fuel flow rate was measured using a standard burette fuel mete ring system. The various tail pipe emissions such as hydrocarbon (HC), carbon monoxide (CO), smoke and oxides of nitrogen (NO_x) were measured using AVL 437 smoke meter andAVL DI gas exhaust analyzer. The engine cylinder pressure was measured using a quartz piezoelectric transducer. All the experiments were conducted by cranking the engine with diesel fuel and then the engine was switched over to LOME biodiesel i.e. B10, B20, B30 and B40 at various load conditions from no load to full load. The engine performance parameters such as specific fuel consumption (SFC),brake thermal efficiency (BTE) and combustion parameters such as cylinder pressure, rate of pressure rise, net heat release rate and various tailpipe emission parameters such as HC, CO, NO_x, smoke were evaluated.

Fig:4. (a) AVLDI GAS 444 Exhaust gas
Analyzers (EGA) form assuring emission gases (b) Inlet exhaust gas from the engine to EGA

IV. RESULTS AND DISCUSSIONS

4.1. Brake thermal efficiency (BTE)

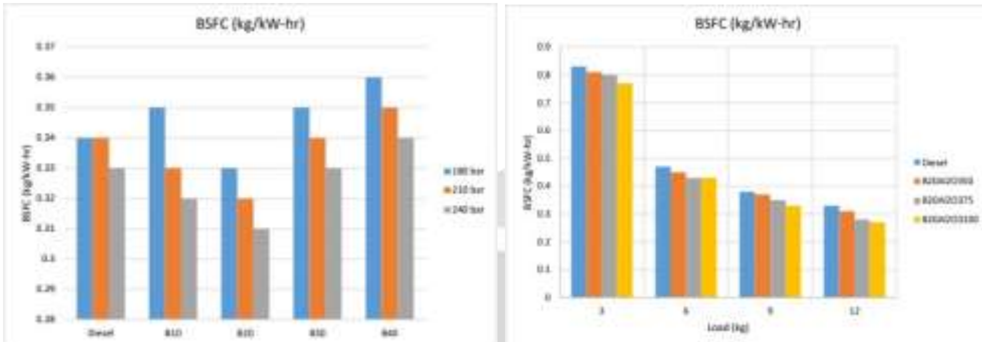
The variation of brake thermal efficiency (BTE) with respect to engine load at three different injection pressures-rated injection pressure of 210 bar, a pressure lower than rated injection pressure i.e. 185 bar and a pressure higher than rated injection pressure i.e. 220 bar for diesel and LOME biodiesel blended fuels. By increasing the injection pressure of the engine to the rated injection pressure of 210 bar, the BTE also get slim proved for all the fuels tested. Increasing the injection pressure beyond the rated value i.e., injection pressure 220 bar, offers decreasing trend on BTE for both diesel and as well as LOME biodiesel blends. Under all the load conditions and injection pressure, diesel fuel produces better brake thermal efficiency than that of LOME biodiesel fuels. The decrease in the calorific value of the LOME biodiesel fuel is responsible for lower BTE as compared to diesel fuel. At all the three injection pressures B20 offers comparable BTE with diesel fuel. The higher BTE at rated injection pressure can be attributed to the effective utilization of the fuel due to better atomization. Additionally, increasing the injection pressure contributes to the rapid start of combustion which in turn prolongs during the expansion stroke of a diesel engine that leads to better combustion which enables the engine to attain higher BTE while operating it with rated injection pressure.



Graph:4.1.Comparison of BTE for the LGME with diesel

4.2. Brake Specific Fuel Consumption (BSFC)

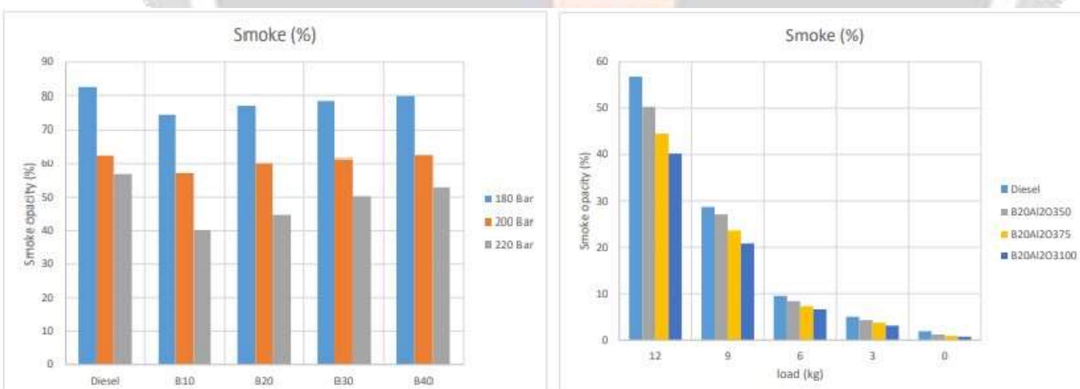
It is well known that the specific fuel consumption (SFC) and calorific value (CV) of the fuel are the two inf luential factors for engine performance. The variation of SFC vers us engine load for different LOM biodiesel blends and diesel at a fuel injection pressure of 185 bar, 210 bar and, 220 bar respectively. , SFC of all the fuels decreases with an increase in engine load. At maximum engine load condition, the SFC of all blends of LOME biodiesel was found marginally closer to diesel. This is due to the collective effect of viscosity, density and calorific value of LOME biodiesel. When the fuel injection pressure increases, it simultaneously decreases the fuel droplet size resulting in better mixing and vaporization of the fuel and thereby reduces the specific fuel consumption for all the fuels tested. However, at all the fuel injection pressures for diesel fuel, the SFC is lower than that of LOME biodiesel due to its higher calorific value and lower density. Because of higher calorific value and lower density of diesel fuel, less diesel fuel was required to develop an equal amount of engine brake power compared with LOME biodiesel fuel.



Graph: 4.2. Comparison of BSFC for the LGME with diesel

4.3. Smoke

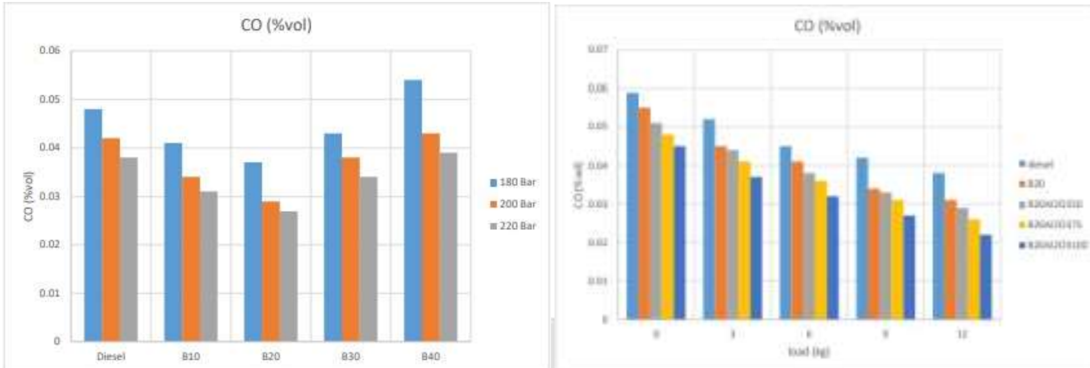
The smoke opacity variation with the engine load and fuel injection pressure for diesel as well as WMS biodiesel blends for all the tested fuels, the smoke opacity increases with an increase in engine load. Further the increase in fuel injection pressure reduces the smoke opacity. At the rated injection pressure of 210 bar and full load condition, the smoke opacity of B10, B20, B30 and B40 get decreased by about 1.3 %, 2.9 % and, 8.9 %, 9.1 % respectively as compared to diesel. As compared to 210 bar injection pressure, the smoke opacity decreases by about 9.5 %, 22.1 %, 35.1 % and 42 % for diesel, B20 Al_2O_3 50, B20 Al_2O_3 75, and B20 Al_2O_3 100 respectively at 220 bar fuel injection pressure. The increased combustion pressure and combustion temperature at higher fuel injection pressure and the presence of higher oxygen content with WMS20 fuel make the local and global air-fuel mixture is leaner which is favorable for lesser smoke formation inside the combustion chamber.



Graph:4.3. Comparison of Smoke for the LGME with diesel

4.4. CarbonMonoxide(CO)

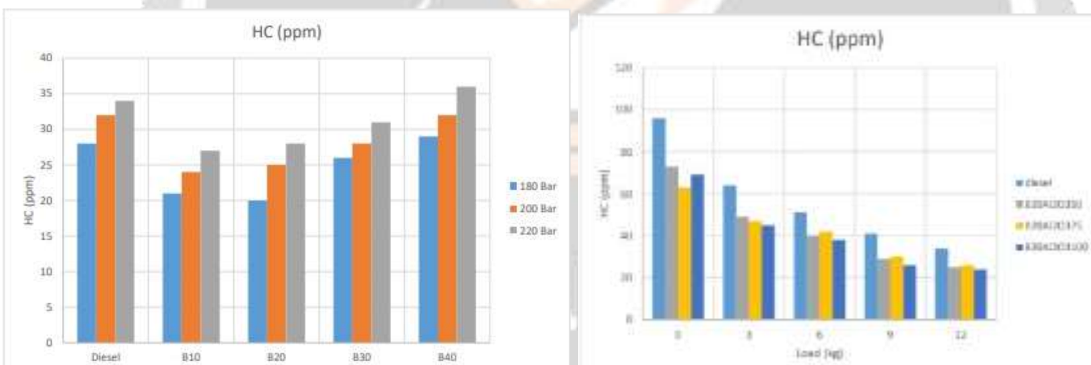
The effect of injection pressure on carbon monoxide (CO) concentration for diesel and various LOME biodiesel blend. It is noticed that CO concentration decreases significantly with the increase in injection pressure. The higher combustion temperature inside the engine cylinder is favorable for a reduction in CO concentration. When the injection pressure increases, it augments simultaneously the combustion temperature and thereby promotes the oxidation rate of CO to form carbon dioxide (CO_2) which results in lesser CO. Moreover, the CO concentration of B20 biodiesel at 220 bar is lower than180 bar injection pressure due to the higher oxygen content of the fuel as compared to diesel. Also, the higher oxygen content present in the LOME biodiesel is responsible for complete combustion and there by reduces the oxidation time for converting carbon monoxide to carbon dioxide.



Graph: 4.4. Comparison of CO for the LGME with diesel

4.5. HydroCarbons (HC)

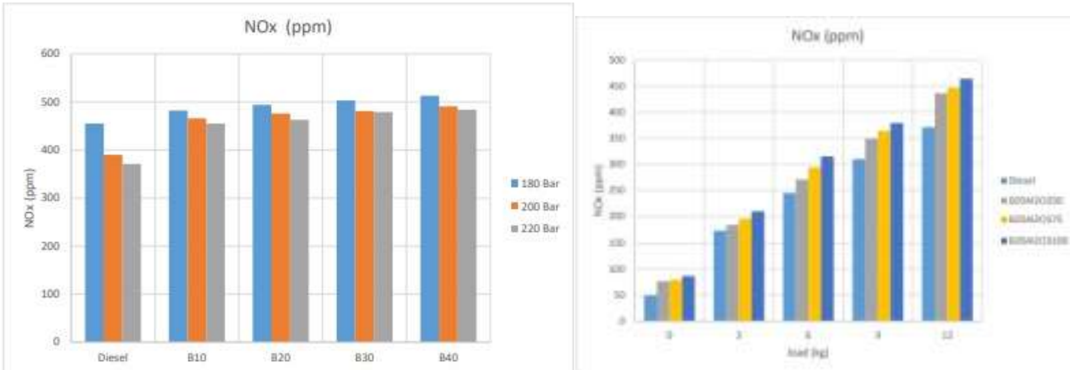
The variation of HC with engine load at injection pressures of 185 bar, 210 bar, and 220 bar respectively. It is noticed that due to better combustion, HC concentrations were lower for all the blends of LOME biodiesel at all the injection pressures than that of diesel fuel. Further, with the increase in the blend percentage of LOME, unburnt hydrocarbon had diminished due to increased oxygen content. However, increasing the fuel injection pressure from 185 bar to 220 bar facilitated the movement of the fuel droplets inside the combustion chamber at a higher velocity which in-turn increased the HC concentrations. It is obvious from that, HC concentrations at 220 bar injection pressure are higher than 180 bar and 200 bar and it increased by about 17.64%, 16.12%, 25% and 25.92% for diesel, B20 Al_2O_3 75, B20 Al_2O_3 50 and B20 Al_2O_3 100 respectively.



Graph: 4.5. Comparison of HC for the LGME with diesel

4.6. Oxides of Nitrogen

The oxides of nitrogen (NO_x) concentration from the engine exhaust represents the combination of nitric oxide (NO) and nitrogen dioxide (NO_2) concentrations. The major factor influencing the formation of NOx is in-cylinder combustion temperature and oxygen availability during combustion. The NO_x concentration increases with the increasing proportion of WMS biodiesel in the blends and increases in injection pressure. At all the engine loads, an increase in fuel injection pressure will resultin increased formation of NO_x concentration due to an increased combustion pressure and heat releaserate. At 220 bar fuel injection pressure, the NO_x concentration increases. Oxides of nitrogen are themajor emissions in an internal combustion engine here in case of biodiesel such as LOME consist of high amount of inbuilt oxygen where during the process of combustion the Aluminum oxide molecule break at high temperature with the evolution of oxygen and this oxygen is utilized by the near by hydrocarbons and come as by products as carbon dioxide and water vapor. Normally the nitrogen is highly stable due to the presence of 3 valence electrons in the outer most orbit. Hence due the high temperatures developing in the engine the nitrogen molecule get energized after it attains the required ionization energy the N_2 breaks and react with the oxygen to the form the oxides of nitrogen.



Graph:4.6.Comparison of Nox for the LGME with diesel

V. CONCLUSION

The investigation of Aluminum oxide Nano additive in water emulsified Diesel-LOME blend on performance and emission parameters of 4-stroke single cylinder diesel engine is done. The obtained results were compared with the conventional diesel. All the observations are drawn from experimental results corresponding to the variation from no load to full load. The comparison of these observations isdone based on the fuel properties, performance and emission characteristics. The following blends were tested and evaluated the results. The following blends were tested based on observations. The brake thermal efficiency of the fuel has been increased with addition of Al_2O_3 nano additive in B20 Al_2O_3 100 at full load i.e., 14.3% more than that of conventional diesel. The addition of Al_2O_3 at specific percentage has slightly reduced the BTE and by addition of Al2O3 increased calorific value there by increasing the efficiency.

There is decrease for B20Al2O3100 in BSFC were seen i.e., 17.6%% less than that of diesel with the expansion of Al_2O_3Nano additive having high calorific value the BSFC is diminished having a tendency to finish burning. There is major decrease in CO is seen for B20$Al_2O_3$100 i.e., 42.3% because of less than that of diesel because of higher oxygen content. There is decrease in CO is seen for B20 i.e., 28.94% less than that of diesel. Rich oxygen content in the biodiesel and addition of Nano particles are the main reasons for the reduction of HC emissions. However, HC emissions were more decreased5.8% for B20 less than diesel. With addition of Al2O3 there is 29.41 % less than that of diesel. There is increase in the NOx is seen such that 22.6% than that of diesel after addition of Al_2O_3 there is 25.06 %more than that of diesel. Smoke is seen decreased 21.6% less than that of diesel. It is seen that with addition of 46 Al_2O_3 there is 29.22 % decrease is seen than that of diesel. From the above investigation B20 Al_2O_3 100 shows better performance and low emission characteristics at all load conditions. It is recommended that B20 Al_2O_3 100 is preferable for 4-stroke single cylinder diesel engine.

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