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Performance and Emission Testing on Algae Bio Fuel using Additives

Tom Varghese, Jesu Raj, E. Raja, C. Thamotharan

ABSTRACT- Due to the depletion of non-renewable fossil fuels there are many alternative fuels introduced today, one of alternative fuel used is Bio-Diesel , but Bio-Diesel has low performance characteristics and not commercially used , Therefore in my experiment I am using algae based biodiesel with blends of Diesel additives and experimental investigation is done to find the engine performance and emission characteristic of a compression ignition engine by using organic materials also some other alcoholic substances as additives to diesel-biodiesel blends .The use of algae as bio-diesel is studied and it has been tested to obtain increased performance and low emission. The Brake thermal efficiency (Bthe) will be increased and the specific fuel consumption (SFC) level will be reduced , The engine emission is noted to have reduced emission of hydrocarbon(HC) emission, Nitrogen oxide(NO_x) emission, Carbon monoxide(CO) emission , It is done first by using pure diesel as base fuel, and then by adding nanoparticles to the diesel-biodiesel blends, which is the modified fuel . Both the fuels and compared based on their performance test and Emission test.

Keywords – Bio-Diesel, (Bthe), (SFC), (NO_x) (CO), (HC)

I. INTRODUCTION

1. 1 Diesel Engine

A diesel engine (also known as a compression-ignition engine) is an internal combustion engine that uses the heat of compression to initiate ignition to burn the fuel that has been injected into the combustion chamber. This is in contrast to spark-ignition engines such as a petrol engine (gasoline engine) or gas engine (using a gaseous fuel as opposed to gasoline), which uses a spark plug to ignite an air-fuel mixture. The engine was developed by German inventor Rudolf Diesel in 1893. The diesel engine has the highest thermal efficiency of any regular internal or external combustion engine due to its very high compression ratio. Low-speed diesel engines (as used in ships and other applications where overall engine weight is relatively unimportant) can have a thermal efficiency that exceeds 50%. Diesel engines are manufactured in two-stroke and four-stroke versions. They were originally used as a more efficient replacement for stationary steam engines. Since the 1910s they have been used in submarines and ships. Use in locomotives, trucks, heavy equipment and electric generating plants followed later. In the 1930s, they slowly began to be used in a few automobiles. Since the 1970s, The cylinders and the crankshaft which drives the pistons can be configured in various ways. Configurations of two-cylinder engine include: Straight-two engine, with two cylinders in parallel sharing a crankshaft V-twin engine, two cylinders sharing a crankshaft at an angle Flat-twin engine, having both cylinders on the same crankshaft at 180° to each other U engine with two cylinders with separate crankshafts the use of diesel engines in larger on-road and off-road vehicles in the USA increased. As of 2007, about 50% of all new car sales in Europe are diesel. Twin cylinder diesel engine A Two-cylinder engine is a reciprocating engine which has two cylinders.

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***** Correspondence Author (s)

Tom Varghese, M. Tech Student, Department of Automobile Engineering, Bharath Institute of Science and Technology. Bharath University, Chennai, India.

Jesu Raj, M.Tech Student, Department of Automobile Engineering, Bharath Institute of Science and Technology. Bharath University, Chennai, India.

E. Raja, Guide, Assistant Professor, Department of Automobile Engineering, Bharath Institute of Science and Technology. Bharath University, Chennai, India.

C. Thamotharan, Project Coordinator, Professor, Department of Automobile Engineering, Bharath Institute of Science and Technology. Bharath University, Chennai, India.

1.2 ALTERNATIVE FUELS

Alternative fuels, known as non-conventional or advanced fuels, are any materials or substances that can be used as fuels, other than conventional fuels. Conventional fuels include: fossil fuels (petroleum (oil), coal, propane, and natural gas), as well as nuclear materials such as uranium and thorium, As well as artificial radioisotope fuels that are made in nuclear reactors, and store their energy. Alternative fuels are derived from resources other than petroleum. Some are produced domestically, reducing our dependence on imported oil, and some are derived from renewable sources. Often, they produce less pollution than gasoline or diesel.

Ethanol is produced domestically from corn and other crops and produces less greenhouse gas emissions than conventional fuels.

Biodiesel is derived from vegetable oils and animal fats. It usually produces less air pollutants than petroleum-based diesel.

Natural gas is a fossil fuel that generates less air pollutants and greenhouse gases.

PROPANE

Propane also called liquefied petroleum gas (LPG), is a domestically abundant fossil fuel that generates less harmful air pollutants and greenhouse gases.

H_2

Hydrogen can be produced domestically from fossil fuels (such as coal), nuclear power, or renewable resources, such as hydropower. Fuel cell vehicles powered by pure hydrogen emit no harmful air pollutants.

1.3. BIODIESEL

Biodiesel is a renewable fuel produced from vegetable oils such as rape seed oil, sunflower seed oil, soybean oil and also used frying oils (UFO) or animal fats. In the transport sector, it may be effectively used both when blended with fossil diesel fuel and inpure form. Tests undertaken by motor manufacturers in the European Union on blends with diesel oil up to 5-10%, or at 25-30% and 100% pure have resulted in guarantees for each type of use. Minor modifications (seals, piping) are required for use at 100% pure, unless specifically guaranteed by car manufacturers. The use of biodiesel as a transport fuel does not require any changes in the distribution system, therefore avoiding expensive infrastructure changes. Biodiesel is also used as an efficient heating oil. Algae based biofuel Algae based biofuels have been hyped in the media as a potential panacea to our Crude Oil based Transportation problems. Algae could yield more than 2000 gallons of fuel per acre per year of production. Algae based fuels are being successfully tested by the U.S. Navy Algae based plastics show potential to reduce waste and the cost per pound of algae plastic is expected to be cheaper than traditional plastic prices. Methanol and Ethanol fuel are typically a primary sources of energy; they are convenient fuels for storing and transporting energy. These alcohols can be used in "internal combustion engines as alternative fuels", with butanol also having known advantages, such as being the only alcohol- based motor fuel that can be transported readily by existing petroleum-product pipeline networks, instead of only by tanker trucks and railroad cars. Biodiesel use Biodiesel has been demonstrated to have significant environmental benefits in terms of decreased global warming impacts, reduced emissions, greater energy independence and a positive impact on agriculture. Various studies have estimated that the use of 1 kg of biodiesel leads to the reduction of some 3 kg of CO2. Hence, the use of biodiesel results in a significant reduction in CO2 emission (65%-90% less than conventional diesel), particulate emissions and other harmful emissions. Biodiesel is extremely low in sulphur, and has a high lubricity and fast biodegradability. These are all advantages which have been confirmed by various EC Commission programmes and tests of independent research institutes. As such, an increased use of biodiesel in Europe represents an important step for the European Union to meet its emission reduction target as agreed under the Kyoto agreement. Additionally reducing pollutant emissions alleviates various human health problems.

1.4. ENGINE EMISSION CONTROL

Vehicle emissions control is the study and practice of reducing the motor vehicle emissions -- emissions produced by motor vehicles, especially internal combustion engines.

Emissions of many air pollutants have been shown to have variety of negative effects on public health and the natural environment. Emissions that are principal pollutants of concern include:

Hydrocarbons - A class of burned or partially burned fuel, hydrocarbons are toxins. Hydrocarbons are a major contributor to smog, which can be a major problem in urban areas. Prolonged exposure to hydrocarbons contributes to asthma, liver disease, lung disease, and cancer. Regulations governing hydrocarbons vary according to type of engine and jurisdiction; in some cases, "non-methane hydrocarbons" are regulated, while in other cases, "total hydrocarbons" are regulated.

Carbon monoxide (CO) - A product of incomplete combustion, carbon monoxide reduces the blood's ability to carry oxygen; overexposure (carbon monoxide poisoning) may be fatal. Carbon Monoxide poisoning is a major killer.

Nitrogen oxides (NO_x) - Generated when nitrogen in the air reacts with oxygen at the high temperature and pressure inside the engine. NO_x is a precursor to smog and acid rain. NO_x is a mixture of NO, N_2O, and NO_2. NO_2 is extremely reactive. It destroys resistance to respiratory infection. NO_x production is increased when an engine runs at its most efficient (i.e. hottest) part of the cycle. Sulfur oxide (SO_x) - A general term for oxides of sulfur, which are emitted frommotor vehicles burning fuel containing sulfur. Reducing the level of fuel sulfreduces the level of Sulfur oxideemitted from the tailpipe.

II. AIM

Experimental investigation are done to find the engine performance and emission characteristic of a compression ignition engine by using some additives to diesel-biodiesel blends.The analysis is done in a compression ignition engine, to find the effects in the performance and emission characteristics. It is done first by using pure diesel as base fuel, and then by adding additives to the diesel-biodiesel blends, which is the modified fuel.

2.1 SCOPE

After measuring the physiochemical properties, it was found, the flash point and viscosity of diesel where found to increase with addition of additives. This results various scope in diesel engine and environmental hazards.

2.3 REDUCTION OF EMISSIONS

In the past, diesel fuel contained higher quantities of sulphur. European emission standards and preferential taxation have forced oil refineries to dramatically reduce the level of sulfur in diesel fuels.

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In the United States, more stringent emission standards have been adopted with the transition to ULSD starting in 2006, and becoming mandatory on June 1, 2010 (see also diesel exhaust). U.S. diesel fuel typically also has a lower cetane number (a measure of ignition quality) than European diesel, resulting in worse cold weather performance and some increase in emissions. High levels of sulfur in diesel are harmful for the environment because they prevent the use of catalytic diesel particulate filters to control diesel particulate emissions, as well as more advanced technologies, such as nitrogen oxide (NO_x) adsorbers (still under development), to reduce emissions. Moreover, sulphur in the fuel is oxidized during combustion, producing sulfur dioxide and sulfur trioxide, that in presence of water rapidly convert to sulfuric acid, one of the chemical processes that results in acid rain. However, the process for lowering sulfur also reduces the lubricity of the fuel, meaning that additives must be put into the fuel to help lubricate engines. Diesel and diesel/petrodiesel blends, with their higher lubricity levels, are increasingly being utilized as an alternative. The U.S. annual consumption of diesel fuel in 2006 was about 190 billion litres (42 billion imperial gallons or 50 billion US gallons).

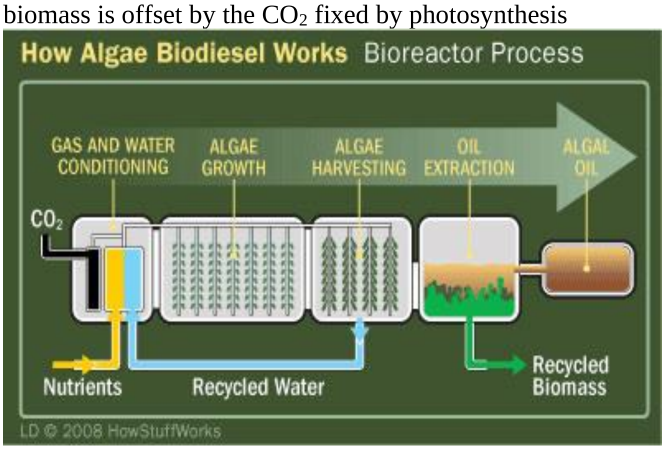
2.4PERFORMANCEINCREMENT OF ENGINE

Diesel is one of the most promising alternatives for diesel needs. Use of edible oil may create shortage of oil seeds for daily food, which necessitates identification of new kinds of non-edible vegetable oil. With this objective, the present work has focused on the performance of castor non-edible vegetable oil and its blend with diesel on a single cylinder, 4 stroke, naturally aspirated, direct injection, water cooled, eddy current dynamometer Kirloskar Diesel Engine at 1500 rpm for variable loads. Initially, castor neat oil and their blends were chosen. The physical and chemical properties of Castor oil were determined. In general, viscosity of neat vegetable oil is high, which can be reduced through blending with diesel and heating them. The heating temperature of the blends increases with the increase in the percentage of neat oils with diesel ranging from 700C to 1200C before entering into the combustion chamber. The suitability of neat Castor oil and their blends are evaluated through experimentation. The performance and emission characteristics of engine are determined using Castor neat oil and their blends with diesel. These results are compared to those of pure diesel. These results are again compared to the other results of neat oils and their blends available in the literature for validation. By analyzing the graphs, it was observed that the performance characteristics are reduced and emission characteristics are increased at the rated load compared to those of diesel. This is mainly due to lower calorific value, high viscosity and delayed combustion process. From the critical analysis of graphs, it can be observed that 25% of neat Castor oil mixed with 75% of diesel is the best suited blend for Diesel engine without heating and without any engine modifications.

III. EXPERIMENTAL, MATERIALS AND METHODS

3.1 Algae bio fuel

The algae used in biodiesel production are usually aquatic unicellular green algae (Chlorophyceae). This type of algae is a photosynthetic eukaryote characterized by high growth rates and high population densities. Under good conditions, green algae can double its biomass in less than 24 hours. Green algae can also have high lipid contents, usually over 50%. This high yield is ideal for intensive agriculture and can be an excellent source for biodiesel production. 3.2 Production of algae biofuel Photosynthesis is the first step in the conversion of light to chemical energy and ultimately responsible for supporting all biofuel synthetic processes, converting solar energy into biomass, carbon storage products (carbohydrates and lipids) and hydrogen. In green algae, light is captured by light harvesting complex proteins, referred to as LHCI and LHCII (Figure 5). Their expression is dependent on environment conditions (light intensity). These proteins bind a large amount of the chlorophyll and carotenoids in the plant and play a role in both light capture and in the dissipation of excess energy, which would otherwise inhibit the photosynthetic reaction centers (photosystem II). Excitation energy used to drive the photosynthetic reactions is funneled to the photosynthetic reaction centers of photosystem I (PSI) and photosystem II (PSII) via the network of pigments bound by the LHC, PSII, and PSI subunits. In the beginning, PSII uses this energy to drive the photosynthetic water splitting reaction, which converts water into protons, electrons and oxygen. The electrons are passed along the photosynthetic electron transport chain via plastoquinone (PQ), cytochrome b_6f (Cyt b_6f), PSI, and ferredoxin (Fd) and on to NADPH. At the same time, protons are released into the thylakoid lumen by PSII and the PQ/PQH_2 cycle. This generates a proton gradient, which drives ATP production via ATP synthase. The protons and electrons are recombined by ferredoxin-$NADP^+$ oxidoreductase (FNR) to produce NADPH. NADPH and ATP are used in the Calvin cycle to produce the sugars, starch, oils that are required to produce bioethanol, biodiesel, and biomethane. The Calvin cycle is an integral part of the photosynthetic process and responsible for fixing CO_2 in a diverse range of organisms including primitive algae through to higher plants. The process uses ATP and NADPH generated by the light reactions. Algal oil is converted into biodiesel through a transesterification process. Oil extracted from the algae is mixed with alcohol and an acid or a base to produce the fatty acid methylesters that makes up the biodiesel. An excess of methanol is used to force the reaction to favor the right side of the equation. The excess methanol is later recovered and reused (Demirbas & Demirbas, 2010). If biomass is grown in a sustained way, its combustion has no impact on the CO_2 balance in the atmosphere, because the CO_2 emitted by the burning of biomass is offset by the CO_2 fixed by photosynthesis



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The most cost-effective way to farm microalgae is in large, circulating ponds. Closed photobioreactors provide sterility and allow for much greater control over culture parameters such as light intensity, carbon dioxide, nutrient levels, and temperature. Under optimal conditions, microalgal populations are capable of doubling within hours and achieving high cell densities (Rosenberg et al., 2008). Besides saving water, energy and chemicals, closed bioreactors have many other advantages, which are increasingly making them the reactor of choice for biofuel production, as their costs are reduced . They support up to fivefold higher productivity with respect to reactor volume and therefore have a smaller "footprint" on a yield basis. This is optimal because the goal is to collect as much solar energy as possible from a given piece of land. Most closed photobioreactors are designed as tubular reactors, plate reactors, or bubble column reactors. To increase efficiency, photobioreactors have to be designed to distribute light over a large surface area in order to provide moderate light intensities for the cells (light dilution). This is usually achieved by arranging tubular reactors in a fence-like construction. The fences are oriented in a north/south direction to prevent direct bright light hitting the surface. In this way sunlight is diluted in a horizontal and vertical direction (Schenk et al., 2008). A tubular photobioreactor consists of an array of straight transparent tubes that are usually made of plastic or glass . This tubular array, or the solar collector, captures the sunlight for photosynthesis. The solar collector tubes are generally less than 0.1 m in diameter to enable the light to penetrate into a significant volume of the suspended cells. The ground beneath the solar collector is either painted white or covered with white sheets of plastic to increase reflectance, which will increase the total light received by the tubes. (Christi, 2007).

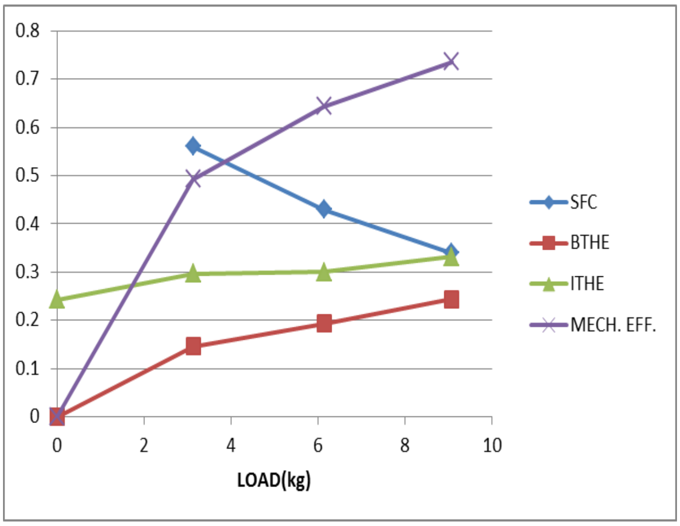
3.3 ALGAE-FUEL PROPERTIES

Algae biodiesel has virtually no sulfur content. Biodiesel has superior lubricating properties, reducing fuel system wear, and increases the life of fuel injection equipment. Algae biodiesel has more aggressive solvent properties than petro diesel and will dissolve leftover varnish residue. Fuel filters should be changed shortly after introducing biodiesel into systems formerly running on petrodiesel to avoid clogging. Biodiesel has about 5-8 percent less energy density than petrodiesel, but with its higher combustion efficiency and better lubricity to partially compensate, its overall fuel efficiency decrease is only about 2 percent. The cloud point, or temperature at which pure (B100) biodiesel starts to gel, is about 32 ^{0}F. A blend of B20 (20% biodiesel, 80% petrodiesel) generally does not gel in cold weather. Various additives will lower the gel point of B100. Biodiesel's flash point (lowest temperature at which it can vaporize to form an ignitable mixture in air) is 266^{0}F, significantly higher than petrodiesel's 147^{0}F, or gasoline's 52^{0}F. Biodiesel reduces particulate matter by about 47 percent as compared to petroleum diesel.

Properties	Diesel	Algae biofuel
Density (kg/m^3)	829	862
Specific gravity	0.829	0.862
Kinematic Viscosity (CST)	25.7	36.7
Flash Point (°C)	37	194
Fire Point (°C)	40	210
Cetane Number	52	50
Calorific value (kJ/kg)	43000	39940

IV. RESULT AND ANALYSIS

The ASTM standard tests to determine various physicochemical properties of the base fuels (Bio diesel) as well as the modified fuels were carried out under identical laboratory condition so that the results could be compared. The primary objectives of this investigation were to determine the variations in the properties of the fuels, due to the addition of the additives and to estimate the effect of the level of inclusion of the others (dosing level) on these variations. Performance tests were conducted on the diesel engine using the modified fuel samples and compared with those with the base fuels, to determine the engine performance enhancement and the reduction of emissions, due to the addition of the catalyst. Based on the experimental results, the variations in the physicochemical properties of the fuel, and the variations in the efficiency and emissions of the CI engine using the modified fuels were determined with various dosing levels as given below. Some indications on the existence of optimum additive nanoparticle dosing levels were also obtained as discussed in this section.



Graph 1- sfc , bthe , ithe & mech.eff

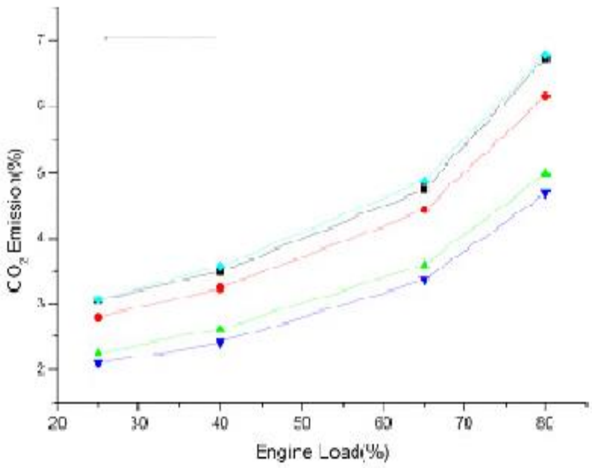


Fig 3. Effect of biodiesel and engine load on CO_2 emission

Graph 2-CO2 emission characterstics graph

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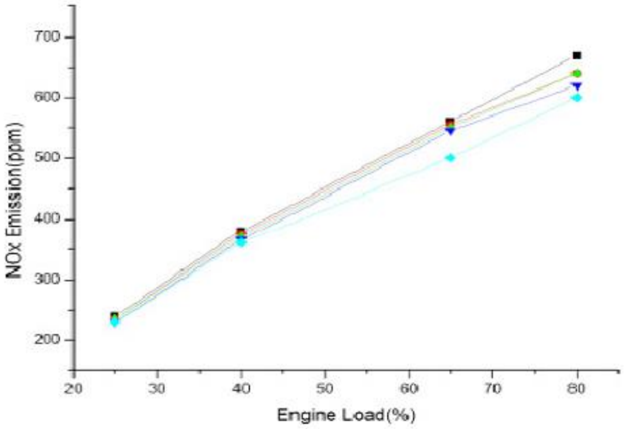


Fig.4. Effect of biodiesel and engine load on NO_x emission

graph 3- nox emission characterstics

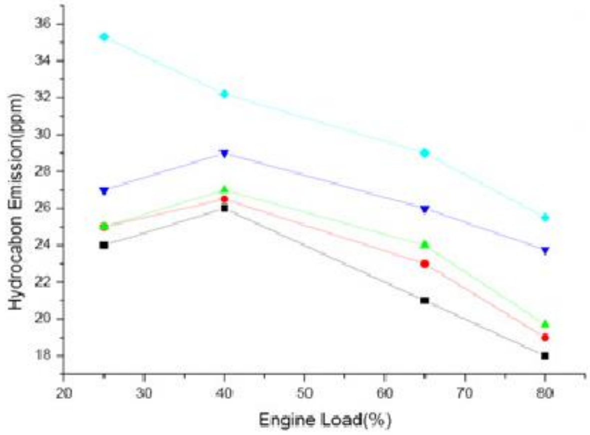
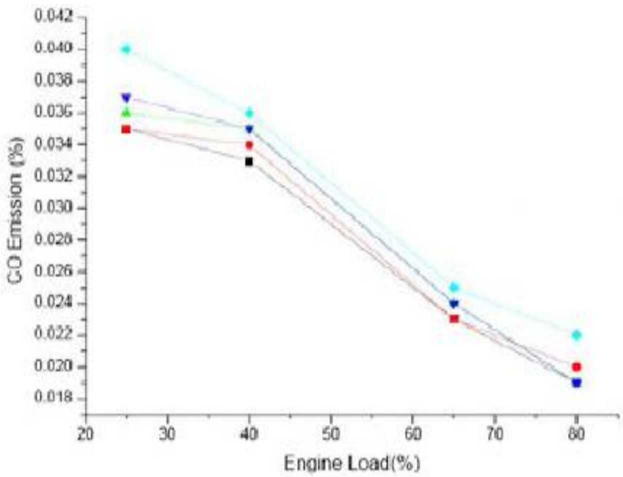


Fig.1. Effect of biodiesel and engine load on hydrocarbon emission

Graph 4- HC emission characterstics graph



Graph 5- CO emission characterstics graph

V. CONCLUSIONS

The experiment was conducted in kirloskar AV-1 Engine. In this experiment along with the disel fuel, algae oil is used with various blends. The algae oil blended with sole fuel in the ratio of B20, B30, and B40

The experiment was successfully conducted and the following results are obtained:

- For B20 blends show the maximum brake thermal efficiency than the other blends.
- The smoke density for all the blends increases, however the B20 shows lower smoke density.
- Up to a part load the NOx emission increases behind that NOx level gradually decreases all the blends.
- Expect the maximum load the CO emission decreases in all blends B40shows the lower CO emission.
- The HC emission for all the blends decreases compared to the diesel fuel.

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