Experimental Investigation of Biodiesel using Nano additives in Diesel Engine

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Abstract— Objective: To determine the engine performance and emissions of a single cylinder Direct Injection (DI) diesel engine using diesel-biodiesel blends with nano additive. Method: Blends of diesel-biodiesel of different proportions are prepared, to which Nano additive Cerium Oxide (CeO2) is added. Properties like Flash point, Fire point, Calorific values are established for these blends. This fuel is used in single cylinder Direct Injection (DI) 4-strok diesel engine and performance of the engine is recorded along with emission details. Finding: In this present investigation cotton seed oil is taken as base oil (biodiesel) and Cerium Oxide (CeO2) as Nano additive. By using by using different blends of cotton seed oil methyl esters, for which Cerium Oxide (CeO2) Nano additives of size 30-50 nm is added in different proportions with neat diesel fuel. The experiments will conduct on a single cylinder Direct Injection (DI) 4-stroke diesel engine, and observed the variation of Specific Fuel Consumption (SFC), Brake Thermal Efficiency, Air-Fuel ratio, Exhaust Gas Temperature (EGT), NOx emissions, Carbon Monoxide (CO), and Hydro Carbons (HC) emissions. Experimental result are The results have shown lower fuel consumption, better performance, and lower emissions of Carbon Monoxide (CO), Hydro Carbons (HC) but higher emissions of (NOx), in comparison to neat diesel fuel.

Key words: Wireless Sensor Networks, WSNs Design, Network Topologies, OSI Model Layers, Sensor Nodes

I. INTRODUCTION

A. *Biodiesel:*

Biodiesel is receiving serious attention globally as a potential alternative fuel for replacing mineral diesel, partially or fully. In this review paper, most prominent methods of biodiesel production commercially, life-cycle analysis and economic issues related to biodiesel, engine performance, combustion and emission characteristics including particulate, engine compatibility issues and effect of biodiesel usage on engine component wear and lubricating oil are comprehensively discussed. Majority of biodiesel produced globally is via base-catalyzed Tran's esterification process since this is a low temperature and pressure process, having high conversion rates without intermediate steps, and it uses inexpensive materials of construction for the plant.

Catalyst types (alkaline, acidic or enzymatic), catalyst concentration, molar ratio of alcohol/oil, reaction temperature, moisture content of reactants, and free fatty acid (FFA) content of oil are the main factors affecting biodiesel (ester) yield from the trans esterification process. Substantial reduction in particulate matter (PM), total hydrocarbons (THC) and carbon monoxide (CO) emissions in comparison to mineral diesel, and increased brake specific fuel consumption (BSFC) and oxides of nitrogen (NO_X) emissions are reported by most researchers using unmodified compression ignition (CI) engines. This review covers several aspects, which are not covered by previous review articles, such as effect of biodiesel on unregulated emissions, effect of biodiesel on carbon deposits, wear of key engine components, and lubricating oil in long-term endurance studies. It emerges from literature review that even minor blends of biodiesel help control emissions and ease pressure on scarce petroleum resources without sacrificing engine power output, engine performance and fuel economy. This review underscores that future studies should focus on optimization of fuel injection equipment and hardware modifications to develop dedicated biodiesel engines, improve low temperature performance of biodiesel fuelled engines, develop new biodiesel compatible lubricating oil formulations and special materials for engine components before implementing large-scale substitution of mineral diesel by biodiesel globally. Biodiesel is conceived as a renewable and environment-friendly fuel benignant to petro-diesel, with benefits of lower level of smoke, unburned hydrocarbons and carbon monoxide than petro-diesel. [2]

It is easier to achieve clean combustion with biodiesel, resulting in reduced level of exhaust emission by using oxygenates as additives antioxidants as additives and nanoparticles as additives in biodiesel. Recently, many researchers focused their attention on fuel formulation technique for achieving better performance and emission characteristics. Among the recent fuel additives to biodiesel, the nanoparticles as additive in biodiesel has emerged as a new promising fuel additive for achieving utmost improvement in the performance and level best reduction of exhaust emission. The observed that the nanoparticles dispersed test fuels shows better thermo physical properties due to its higher surface to volume ratio and acts as an oxygen buffer with respect to NO emission. It's observed that nanoparticles enhance the heat transfer rates due to its higher specific surface area. Experimentally studied the promotion of cerium oxide nanoparticles with ethanol and revealed that nanoparticles can be used as a fuel borne additive in hydrocarbon liquid fuels. Employed ceria nanoparticles as additive in diesel emulsion fuel and found significant reduction of Particulate Matter, CO, and UBHC emission. The studied the working characteristics of a single cylinder diesel engine by using aluminum nanoparticles of 3 and 6% volume separately in diesel and found significant reduction of fuel consumption, smoke and NO emission. The conducted experiments in computerized single cylinder, four stroke, and DI variable compression ratio engine by using cerium oxide nanoparticles as additive in diesel and biodiesel-ethanol blends and observed substantial reduction of exhaust emission with marginal improvement in the brake thermal efficiency.[2]

The conducted experiments in a naturally aspirated, four stroke, single cylinder, water cooled compression ignition engine to study the effect of cerium oxide nanoparticles dispersed at 20 to 80 ppm in Atrophy biodiesel for evaluating the engine performance and emission characteristics and resulted with significant reduction of NO by 30% and UBHC by 40% for cerium oxide nanoparticles dispersed test fuel, besides percentage improvement of brake thermal efficiency by 1.5%.

B. Cottonseed Oil

Biodiesel is derived from vegetable oils or animal fats through Tran's esterification. Trans esterification is also called alcoholysis, which uses alcohols in the presence of catalyst (e.g., base, acid or enzyme depending on the free fatty acid content of the raw material) that chemically breaks the molecules of triglycerides into alkyl esters as biodiesel fuels and glycerol as a by-product. The commonly used alcohols for the trans esterification include methanol, ethanol, propanol, butanol, and amyl alcohol. Methanol and ethanol are adopted most frequently, particularly the former due to its low cost. Commonly used feedstocks (vegetable oil) for transesterification include soybean oil, rapeseed oil, etc.

In recent years, there exist active researches on biodiesel production from cottonseed oil, of which the conversion between 72% and 94% was obtained by enzyme catalyzed transesterification when the refined cottonseed oil reacted with short-chain primary and secondary alcohols. The application of solid acid catalysts on cottonseed oil transesterification. The results showed that the yield of methyl ester was above 90% after 8 hours of reaction.In contrast, transesterifying cottonseed oil by microwave irradiation could produce a biodiesel yield in the range of 89.5-92.7%. No matter what kind of catalysts or approaches were applied, all those studies aimed to produce high yield of biodiesel by optimized reaction conditions based on optimized parameters in terms of alcohol/oil molar ratio, catalyst concentration, reaction temperature.[2]

C. Cerium Oxide Nano-Particle–

The diesel engines are generally more efficient than spark ignition engines but the engine emissions from the burning of fuel in the diesel engine are higher. This has the negative impact on its wide acceptance and uses, especially in automotive applications. Recently govt. of India start following the new engine emission norms Bharat Stage-IV all over in country in order to regulate the pollutants comes out after burning of fuel in internal combustion engine & spark ignition engine, mostly Knox, particulate matter, hydrocarbons. Biodiesel contains 10-15% more oxygen and absence of sulfur so, it leads to improve complete combustion and reduce the engine emissions as compare with diesel but the calorific value of biodiesel-diesel blends can reduce the % of fuel demand all over in the world. The engine emissions are affected by properties of fuel such volatility, density, flash point, fire point, viscosity etc. those properties of fuel alter by adding fuel additives. The ASTM distillation curve represent by the volatility of the diesel, viscosity of fuel affects lubrication and optimization of charge while the flashpoint, fire point represents the lowest temperature below which the fuel handle safely. So it is appropriate method to change the physiochemical properties to optimize the combustion process. Generally biodiesels are produce from trans-etherification process on fatty acids so contains nearly 16% more oxygen as compare with diesel which causes the emission of NOx. The stability of nanoparticles can improved by adding appropriate surfactant in blend and ultrasonication process of dispersion of nanoparticles in blends mixing well in proportion and following by agitator stabilizes the nanoparticles in fuel.

Nano scale ceriumoxide is used as a diesel fuel additive to reduce particulate matter emissions and increase fuel economy, but its fate in the environment has not been established. Cerium oxide released as a result of the combustion of diesel fuel containing the additive Envirox, which utilizes suspended nanoscale cerium oxide to reduce particulate matter emissions and increase fuel economy, was captured from the exhaust stream of a diesel engine and was characterized using a combination of bulk analytical techniques and high resolution transmission electron microscopy. The combustion process induced significant changes in the size and morphology of the particles; ∼15 nm aggregates consisting of 5−7 nm faceted crystals in the fuel additive became 50–300 nm, near-spherical, single crystals in the exhaust. Electron diffraction identified the original cerium oxide particles as cerium (IV) oxide (CeO_2, standard FCC structure) with no detectable quantities of Ce(III), whereas in the exhaust the ceria particles had additional electron diffraction reflections indicative of a CeO_2 superstructure containing ordered oxygen vacancies. The surfactant coating present on the cerium oxide particles in the additive was lost during combustion, but in roughly 30% of the observed particles in the exhaust, a new surface coating formed, approximately 2–5 nm thick.

The results of this study suggest that pristine, laboratory-produced, nanoscale cerium oxide is not a good substitute for the cerium oxide released from fuel-borne catalyst applications and that future toxicity experiments and modeling will require the use/consideration of more realistic materials.

Sr.No	Year's	Petrol Demand (MT)	Diesel Demand (MT)	Biodiesel blending requirement. (MT) at 20%
1	2006-07	10.07	52.32	10.46
2	2011-12	12.85	66.91	13.38
3	2016-17	16.40	83.58	16.72

Table 1.3.1: Requirement of fuel.

II. Fuel Preparation

Cottonseed oil is taken as biodiesel and diesel-biodiesel blend is used for finding out the performance of the direct injection diesel engine. Maximum 50 per cent of biodiesel is mixed with diesel to balance viscosity. In this investigation, Cerium Oxide (CeO2) is taken as Nano additive to the diesel-biodiesel blend and performance tests are conducted on the same engine. After checking engine condition along with lubricating oil level, metered gravity of fuel is supplied to the engine on its start and engine is run initially for 30 minutes to pick up the rated speed.

III. Design of Experiment

Sr.No.	Fuel	Flash point (0c)	Fire point (0c)	Calorific value (kj/kg)
1	Diesel	53	58	43800
2	B20	87	94	41050
3	B50	108	118	40500
4	B20+ 0.04gm CeO2	81	84	41162
5	B50+ 0.04gm CeO2	93	96	40980
6	B20+ 0.08gm CeO2	76	82	41134
7	B50+0.08gm CeO2	94	98	40957

The following are the fuel samples, Diesel, B20 (80 percentage diesel and 20 percentage biodiesel in volume), B50 (50 percentage diesel and 50 percentage biodiesel in volume), B20+0.04 gm CeO2(80 percentage diesel and 20 percentage biodiesel and 0.04 gm (40 mg/l) cerium oxide) in volume, B20 + 0.08 gm CeO2 (80 percentage diesel and 20 percentage biodiesel and 0.08 gm (80 mg/l) cerium oxide) in volume, B50 + 0.04 gm CeO2 (50 percentage diesel and 50 percentage biodiesel and 0.04 gm (40 mg/l) cerium oxide) in volume, B50 + 0.08 gm CeO2 (50 percentage diesel and 50 percentage biodiesel and 0.08 gm (80 mg/l) cerium oxide) in volume respectively.

The Taguchi optimization is apply to optimize Concentration of nano particle, additives and % of biodiesel.

The major steps of implementing the Taguchi method are:

1) To identify the factors/interactions
2) To identify the levels of each factor
3) To select an appropriate orthogonal array (OA)
4) To assign the factors/interactions to columns of the OA
5) To conduct the experiments
6) To analyze the data and determine the optimal levels
7) To conduct the confirmation experiment

A. Experimentation and Mathematical Modeling:

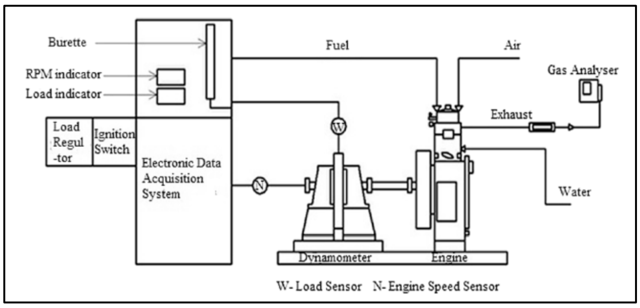
1) Experimentation:

1) Preparation of nano particle in to required size and taking the SEM
2) Fuel samples - Different % of nano additives and biodiesel.
3) To check its required properties like C.N., C.V. density, and viscosity etc.
4) Experimentation is done on single cylinder, 4 stroke, and constant speed, VCR diesel engine with different loads.
5) Performance parameters and Emissions are measured by the apparatus attracted to the test engine (Dynamometer, Gas analyzer and smoke meter etc.)

B. Mathematical Modeling:

- Mathematical models are prepared from experimental Results by using Regression Analysis.
- Parameters for Mathematical modeling-
  1) BTE (η)
  2) BSFE(S)
  3) B.m.e.p
- Variables for mathematical modeling-
  1) Compression Ratio(C).
  2) Size of nano particles (N)
  3) Nano Additives Percentage (D)
  4) Biodiesel percentage(B)

IV. Experimental Setup



V. Expected Outcomes

In this work, The performance and emissions of Biodiesel (Cotton seed oil) were studied on resent research study. The Cerium Oxide (CeO2) as additive in biodiesel plus diesel, The up to the recent research, it is seen that the following results are obtained from different researchers, They try to very well to reducing the smoke particle like CO, HC, NOx, CO_2 etc.. but NOx emission is increases at full load and also try to increases BTE (Break Thermal Efficiency), BSFC(Break specific fuel consumption) and reducing the

SFC (Specific Fuel Consumption), EGT (Exhaust Gas Temperature) etc. Now in this work our expected result are to reducing the smoke pollutant basically NO_x emission and other parameters which is discussed above.

VI. Efficiency

- It can be increased by 0.1%to0.3% increasing brake power as well as decreases BSFC. Brake thermal efficiency increase with higher brake power and emission level
- From previous result (CeO2 ZnO) increases in CV and Decreases in flash / fire point.

VII. Emissions

With biodiesel-diesel blends its found that lower the CO and lower the smoke emission in comparision to that of diesel fuel but higher oxides NOx are emitted. Oil which is optimally mixed with diesel resulting in low emission and thereby reducing the fossil fuel consumption.

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