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Effect Of Aluminium Oxide Nanoparticles As Additive In Jatropha Oil On Performance And Emission Characteristics Of A Ci Engine

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Abstract— **In day to day life, we are in need of alternative fuel to create an eco-friendly environment and also to meet out the increasing energy consumption rates. The use of alternative fuels considerably decreases harmful exhaust emissions as well as ozone producing emissions. The specific characteristics such as renewability, sustainability and clean burning capacity put ahead the bio-diesels as one among the best choice for alternative fuels. This study deals with an experimentalwork that aims to examine the effects of Aluminium oxide nanoparticles added to Jatropha Biodiesel. In the present work, Jatropha Biodiesel purchased from authorized agencies, and their important physical & chemical properties were tested & compared. It is found that these properties are approximately similar to diesel fuel and suitable to use in diesel engine. Experiments were conducted to determine engine performance, emissions and combustion characteristics of a single cylinder diesel engine using Diesel and Jatropha biodiesel (J100). Along with this J100 Aluminium oxide nanoparticles were added as additive in mass fractions of 50ppm (J100+50ppmAO) with the help of an Ultrasonicator. The performance can be improved by addition of nanoparticles whereas nanoparticles addition leads to high NO_x emission. The NO_x emission is controlled by retarding the injection timing.**

keywords— **Jatropha biodiesel; Performance; Emission; Aluminium oxide nanoparticles; Retarding injection timing**

I. INTRODUCTION

Diesel engines achieve their high performance and excellent fuel economy by compressing air at high pressures, then injecting a small amount of fuel into this highly compressed air. This contrasts with spark ignition engines such as a petrol engine which use a spark plug to ignite an air fuel mixture. The diesel engine has the higher thermal efficiency compared to all internal or external combustion engines due to high compression ratio and lean burn which enables heat dissipation by the excess air. Diesel engines are manufactured in two stroke and four stroke versions. Now-a-days the two stroke engine are banned in the automobiles but used in marine applications, due to the pollution coming out from the two stroke engines are very high compared to the four stroke engines. In diesel engine combustion is mainly depends on the compression pressure and auto ignition temperature of the fuel. The diesel engine plays a vital role in all fields like agriculture, industrial, power production and automobiles etc. High Particulate Matter and Oxides of Nitrogen emission remains a challenge of technical issues for the diesel engine today. By considering the human health in account the researchers are examined a new techniques for reduction of NOx, smoke, and hydrocarbon emissions coming out from the engine the certain modifications are exhaust gas recirculation, increasing the injection pressure, and retarding or advancing the injection timing results in better reduction of emission and fuel economy. Though diesel engines have high thermal efficiency, high torque capacity and produce less HC and CO emissions compared to gasoline engines, they emit NOx and smoke that is a great threat for clean environmental and human health.

II. MATERIALS USED AND METHODS

JATROPHA BIODIESEL

Biodiesel is an alternative fuel similar to conventional or ‘Fossil’ diesel. Biodiesel can be produced from straight vegetable oils, animal fats and waste cooking oil. The process used to covert these oils to biodiesel is called transesterification which takes place between a vegetable oil and an alcohol in the presence of a catalyst. Transesterification is basically a chronological reaction. Triglycerides are first reduced to diglycerides. The diglycerides are subsequently reduced to monoglycerides. The monoglycerides are finally reduced to fatty acid esters. Equipments used for transesterification reaction are magnetic stirrer, thermometer, and beaker. Jatropha is a family of plants that grows in Central America, Africa, the tropical countries of Asia and Australia. These plants are extremely hardy, can stand very dry and harsh weather condition and are known to be able to resist pests to a great extent. On the con side, this tree produces some toxic materials such as saponin, lectin, and phorbol. Recently, these plants are becoming objects of much interest and speculations around the world because they are claimed to be the best sources of biodiesel. The jatropha seeds, commonly known as the physic nuts, contain up to 40% oil. The jatropha oil can be used directly as biofuel or can be converted into biodiesel for a more efficient performance. When raw or mixed jatropha oil is directly used in an automobile or even plane engines, there is some residue, which can be used as biomass in power plants to produce electricity.

Figure 2.1 Jatropha Oil Extractions

As these plants can grow in very harsh weather conditions and has amazing adaptability, it can be cultivated in large barren areas in any country. In India, the government has undertaken many projects to cultivate jatropha in unused lands in order to produce biodiesel in the future. The three-wheeled public vehicles in India, known as auto-rickshaws are going to use only biodiesel in near future. Also, the railway authority in India is running many railway engines on biodiesel.

NANOPARTICLES

Nanoparticles are otherwise called as Nanomaterials. Nanoparticles are small clusters of atoms about 1 to 100 nanometers long. 'Nano' derives from the Greek word "nanos", which means dwarf or extremely small. It can be used as a prefix for any unit like a second or a litre to mean a billionth of that unit. A nanosecond is a billionth of a second. A nanoliter is a billionth of a litre. And therefore a nanometer is a billionth of a meter or 10-9 m.

SEM IMAGES OF ALUMINIUM OXIDE NANOPARTICLES

The size of the crystals is very important in nanomaterials to evaluate the mechanical and chemical properties. The figure shows the particle morphologies of Al_2O_3 particles synthesized using different precipitant. SEM image of Aluminium oxide nano powder for the ammonia water sample is shown in Figure 1a. Large chunks of powder aggregates made up of fine particles are seen. Particles in Figure 1b display poor contrast agglomeration amongst extremely fine particles. Particles obtained by oxalic acid are about 100-300 nm in size and displays spherical shape in comparison to the nanorod shape obtained by ammonia water in Figure. The mean size of aluminium oxide nanoparticles varies from 25 to 50 nm.

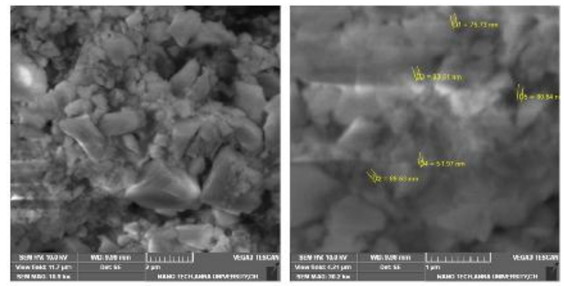

Figure 2.2 Sem images of Aluminium Oxide

For the blending of Aluminium oxide nanoparticles in biodiesel, taken a sample of Jatropha biodiesel say 1litre and then 0.05g of aluminium oxide in the nanoparticles form is added to make the dosing level of 50 ppm. The dosing level of 50 ppm is 0.05 g/l, respectively. After the addition of Aluminium oxide nanoparticles, it is shaken well and then it is poured into mechanical homogenizer apparatus where it is agitated for about 30 min in an ultrasonic vibrator making uniform dispersion. It should be shaken well before use, as excess of nanoparticles settle down on solution.

Properties	Diesel	J100	J100+50ppmAO
Density (kg/m^3)	830 kg/m^3	873 kg/m^3	873 kg/m^3
Calorific value (kJ/kg)	43500 kJ/kg	40969.73 kJ/kg	40974.73 kJ/kg
Kinematic viscosity @40 °C	2.56Centistoke	4.9 Centistoke	4.9 Centistoke
Methanol content	--	0.03 (mass/mass)%	0.03 (mass/mass)%
Cloud point	5^oC	17^oC	18^oC

Table 2.1 Properties of biodiesel blend samples

III. EXPERIMENTAL SETUP

The experimental setup contains an engine, electrical loading by eddy current dynamometer device and measuring equipment. The engine used in this investigation is a four stroke, single cylinder, vertical, and air cooled diesel engine rated at 4.4 kW running at 1500 rpm. The loading is applied by means of an eddy current dynamometer. The fuel tank is connected to a graduated burette, to measure the quantity of fuel consumed in unit time. An orifice meter with U-tube manometer is provided along with an air tank on the suction line for measuring air consumption. The dynamometer is

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calibrated statistically before use. The dynamometer is reversible i.e., it works as monitoring as well as an absorbing device. Load is controlled by changing the field current. The construction of electrical dynamometer has a notched disc (rotor) which is driven by a prime mover and magnetic poles (stators) are located outside with a gap. The coil which excites the magnetic pole is wound in circumferential direction. When current runs through exciting coil, a magnetic flux loop is formed around the exciting coil through stators and a rotor. The rotation of rotor produces density difference, then eddy-current goes to stator. The electromagnetic force is applied opposite to the rotational direction by the product of this eddy- current.

Engine Type	Kirloskar Engine
Bore & stroke	87.5 x110 mm
Swept volume	661.5 cm^3
Injection timing	23^0bTDC
Fuel injection pressure	220 bar
Rated output	4.4 kW
Rated speed	1500 rpm
Compression Ratio	17.5:1
Injection type	Direct injection

Table 3.1 Conventional diesel engine specification

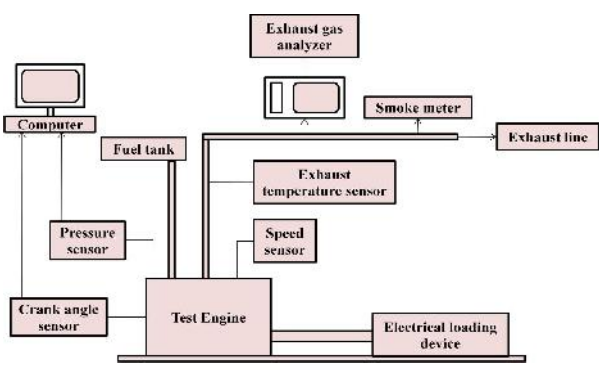

Figure 3.2 Experimental setup

METHOD OF CHANGING THE INJECTION TIMING

Static injection timing of the engine was set by spill method. The steps to retard and advance the injection timing of the engine was performed by various methods as follows. The injector pump side cover was removed that helps you to oversee to insure that the fuel rack pin inside the pump properly aligned with the opening in the top of the pump housing. This pin is vital for proper pump operation so that the injector pump internal unit can be loosened and removed. There are several shims located below the pump top plate is used to vary the injection timing.

IV. RESULT AND DISCUSSIONS

In the present study, the performance, emission, and combustion characteristics of the engine fuelled with diesel, biodiesel (J100) and aluminium oxide nanoparticles blended biodiesel (J100+50ppmAO) fuel blends at normal injection timing(23^0btdc) and retarded injection timing(19^0btdc) were compared and discussed.

4.1 ENGINE PERFORMANCE PARAMETERS

BRAKE SPECIFIC FUEL CONSUMPTION

The tests were performed for pure diesel fuel, biodiesel and aluminium oxide nanoparticle blended biodiesel samples. Experimentally, it was observed that the fuel consumption increases when the load was increased for all operations of diesel, biodiesel and biodiesel blends. The Figure 4.1 shows the variation of brake specific fuel consumption with load for diesel, biodiesel and biodiesel blend of aluminium oxide nanoparticles at normal and retarded injection timing. Retarding the injection timing will decrease the brake specific fuel consumption whereas normal injection timing will increase the brake specific fuel consumption. The brake specific fuel consumption of aluminium oxide blended biodiesel is lower than that of biodiesel (J100) for all loads at both normal and retarded injection timing. Aluminium oxide nanoparticles oxidize the carbon deposits in the engine cylinder leading to reduced fuel consumption. For J100 the increase in fuel consumption was more than that of J100+50ppmAO at both normal and retard injection timings. This was due to the higher viscosity and lower calorific value of J100 as compared to aluminium oxide nanoparticles blended bio diesel. Among the nanoparticles blended bio diesel J100+50ppmAO at 19°btdc has low brake specific fuel consumption.

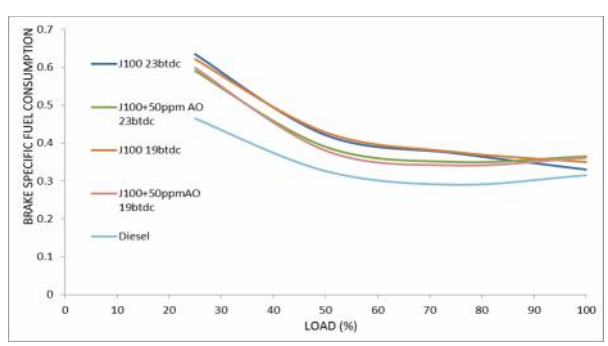

Figure 4.1 Variation of brake specific fuel consumption with percentage of load

BRAKE THERMAL EFFICIENCY

The Brake thermal efficiency is defined as the ratio of work output at the engine shaft to the energy supplied by fuel. It is a measure of the engine's ability to make efficient use of fuel. The Figure 4.2 shows the variation of the brake thermal efficiency with the load. The results show that the brake thermal efficiency of the diesel engine is improved with addition of aluminium oxide nanoparticles in biodiesel. The metal oxide nanoparticles present in the biodiesel blend encourage complete combustion, when compared to the sole biodiesel fuel. Aluminium oxide nanoparticles act as an oxygen buffer and thus improve the Combustion rate and brake thermal efficiency. A maximum increase of 15% in the brake thermal efficiency was obtained for J100+50ppmAO with respect to J100 at both normal and retarded injection timings.

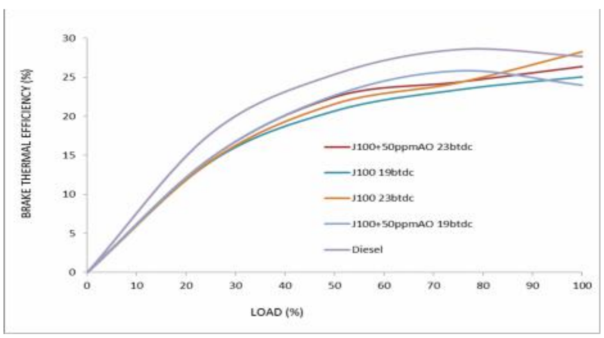

Figure 4.2 Variation of brake thermal efficiency with percentage of load

4.2 EMISSION PARAMETERS

HYDROCARBON EMISSIONS

The Figure 4.3 shows the variation of hydrocarbon emissions for 50 ppm level aluminium oxide nanoparticles in biodiesel blend with respect to biodiesel. Addition of aluminium oxide nanoparticles increased the level of oxygen content in the biodiesel blend. However, oxygen content of fuel is the main reason for HC emission reduction and complete combustion. Hydrocarbon emission is found to be considerably reduced with the addition of the nanoparticles to biodiesel. The Aluminium oxide nanoparticles split the water molecules present in the biodiesel to hydrogen and oxygen molecule. The combustion process is enhanced further due to the presence of hydrogen and oxygen molecule. Hence complete combustion takes place with the addition of nanoparticles in the biodiesel fuel. From this figure , it is seen that the hydrocarbon emission reduced with the addition of aluminium oxide nanoparticles with biodiesel. The hydrocarbon emission of J100 decreased on addition of 50ppm aluminium oxide nanoparticles by about 20% at normal injection timing. The HC emission of J100+50ppmAO at retard injection timing(19°btdc) is low when compared to all the other fuels at both normal and retarded injection timings. Normally HC emissions increases with retarded injection timing whereas in this case the nanoparticles acts as an oxygen buffer and hence it reduces HC emissions.

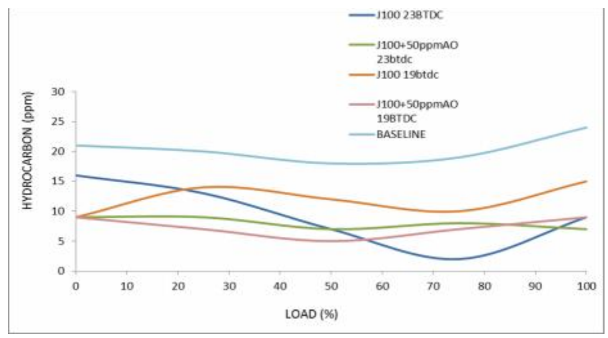

Figure 4.3 Variation of HC emissions with percentage of load

CARBON MONOXIDE EMISSIONS

Carbon monoxide highly relies upon the air-to-fuel proportions comparative to stoichiometric ratio. Figure 4.4 shows the influence of the aluminium oxide nanoparticles addition to biodiesel on carbon monoxide emissions. Nano metal oxide particles as an oxidation catalyst lead to higher carbon combustion activation and hence promote complete combustion. The nanoparticle blended fuels showed accelerated combustion due to the shortened ignition delay. Due to shorten of ignition delay, the degree of fuel–air mixing and uniform burning have enhanced. Due to shorten of ignition delay, the degree of fuel–air mixing and uniform burning have enhanced. Hence, there was an appreciable reduction in carbon monoxide emissions for aluminium oxide blended biodiesel. A maximum decrease of 40% in Carbon monoxide emission was obtained for J100+50ppmAO with respect to J100. As the load on engine increases the Carbon monoxide emission curve decreases. This is due to the increase in Carbon dioxide emissions because of complete combustion. The Carbon monoxide emission of aluminium oxide and nanoparticles blended biodiesel at retarded injection timing is low when compared to baseline diesel. The Carbon monoxide emission of J100+50ppmAO at normal injection timing is low when compared to all other fuel blends at both normal and retarded injection timing.

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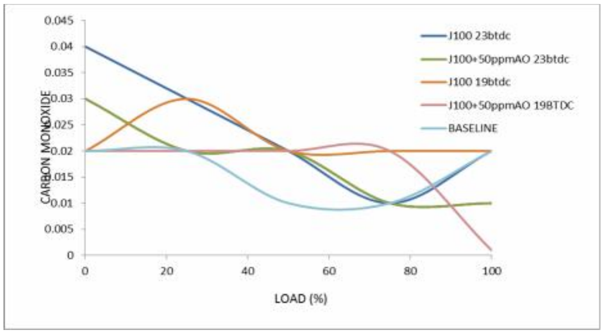

Figure 4.4 Variation of CO emissions with percentage of load

OXIDES OF NITROGEN

The variation of NO_x with respect to load is shown in the figure 4.5. Generally at normal injection timing, the NO_x emission was high. NO_x emission is lower for retarded injection timing when compared with normal condition and diesel. During the retarded injection timing NO_x emission was low at all load conditions. This is due to late start of combustion, the accumulated fuel content is less and therefore low heat release rate which lead to low combustion temperature. Since combustion temperature is directly proportional to the NOx emissions. At retarded injection timing of 19 deg btdc the NOx emissions of J100 is low when compared to all the other fuel blends at normal and retarded injection timings. Among the nanoparticles blended bio diesel fuels, J100+50ppmAO at retarded injection timing emits low NOx. This is because of the low calorific value of jatropha when compare to the diesel. The nanoparticles blended biodiesel at normal injection timing emits more NOx because of the advanced heat release rate and high combustion temperature.

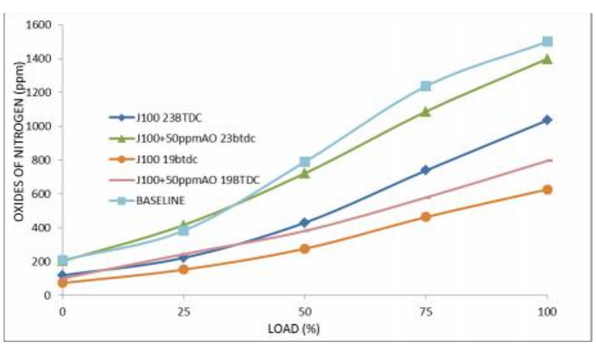

Figure 4.5 Variation of NO_x emissions with percentage of load

SMOKE EMISSIONS

The variation of smoke emissions with respect to load is shown in the figure 4.6. Smoke emission increases as the load increases. As the load increases the amount of fuel injection increases but the time taken for the complete combustion is less. This is the reason behind the maximum smoke density. During normal injection timing there is a sufficient temperature and time for complete combustion and hence smoke density is less when compared to both diesel curve and retarded condition. The aluminium oxide blended biodiesel emit more smoke when compared to diesel. The biodiesel without nanoparticles emits more smoke when compared to other nanoparticles blended biodiesel. This is because of the nanoparticles acting as an oxygen buffer during combustion. At retarded injection timing the emission increases for the same blends.

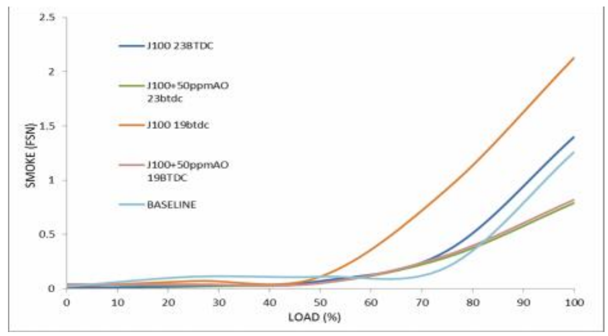

Figure 4.6 Variation of Smoke with percentage of load

III. CONCLUSION

The Present study focus on the influence of aluminium oxide nanoparticles on biodiesel performance, emission and combustion characteristics when charged in compression ignition engine.

- Nearly 20% improvement was observed in brake thermal efficiency for 50 ppm aluminium oxide nanoparticles blended biodiesel compared to biodiesel (J100).
- The brake specific fuel consumption is higher for Jatropha J100 than neat diesel at the entire load and it has reduced to nearly 19% on the addition of aluminium oxide nanoparticles.
- The NOx emissions of Aluminium oxide nanoparticles blended bio diesel at retarded injection timing drastically reduces when comparing to same fuels at normal injection timing.
- With the use of aluminium nanoparticles in biodiesel the CO emissions decreases at normal injection timing whereas CO emissions of nanoparticles blend biodiesel at retarded timing is slightly reduced.

- The addition of aluminium oxide nanoparticles in biodiesel decreases the HC emissions when comparing with neat diesel andJ100 biodiesel.

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APPENDIX

Appendixes, if needed, appear before the acknowledgment.

ACKNOWLEDGMENT

The preferred spelling of the word “acknowledgment” in American English is without an “e” after the “g.” Use the singular heading even if you have many acknowledgments. Avoid expressions such as “One of us (S.B.A.) would like to thank ... .” Instead, write “F. A. Author thanks ... .” **Sponsor and financial support acknowledgments are placed in the unnumbered footnote on the first page**.

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