EXPERIMENTAL INVESTIGATION OF DIESEL ENGINE FUELLED WITH NANOPARTICLES BLENDED BIODIESEL

Pragatheeswaran V[1], Gajendiran M[2], Nallusamy N[3]

[1, 2]*Sri Venkateswara College of Engineering, Post Bag No. 1, Pennalur - 602 117, Sriperumbudur, Tamilnadu, India,*

[3] *SSN College of Engineering, OMR, Kalavakkam - 603 110, Tamil Nadu, India*

E-mail id: pragatheesh.v@gmail.com

ABSTRACT

The rapid running down of gasoline fuels and their ever rising cost have led to an intensive search for alternative fuels. This leads to number of researches on different vegetable oils. Therefore mainly for investigation prefers non-edible oils. Vegetable oils, due to their agricultural origin, are able to reduce CO_2 emissions to the atmosphere along with import substitution of petroleum products. A variety of edible and non-edible oils are considered for bio-diesel production. 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 cerium oxide nanoparticles were added as additive in mass fractions of 50ppm (J100+50ppmCO) with the help of a Ultrasonic vibrator**.** From this investigation the performance characteristics are improved but the oxides of nitrogen (NO_x) emission increases. The main aim is to control the NO_x emission with increase in performance. In this work, the main aim is to control the No_x emission without disturbing the performance is achieved by retarding the injection timing.

Keywords: Jatropha biodiesel; Performance; Emission; Cerium oxide nanoparticles; Retarding injection timing

I.INTRODUCTION

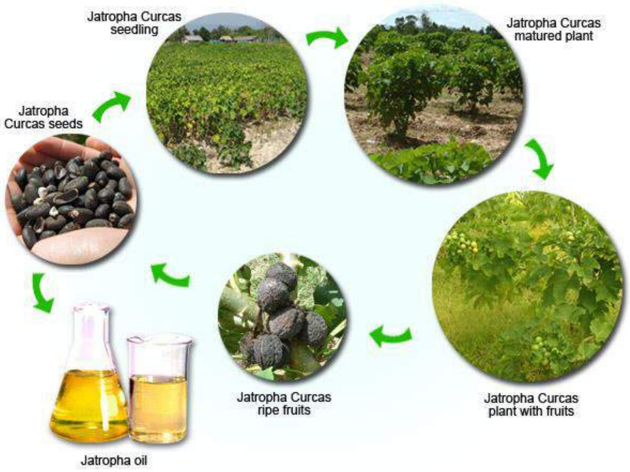
The diesel engine, also known as compression ignition engine or CI engine is an internal combustion engine in which the ignition of the fuel that has been injected into the combustion chamber is initiated by the high temperature which a gas achieves when greatly compressed by adiabatic compression. This 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. 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.

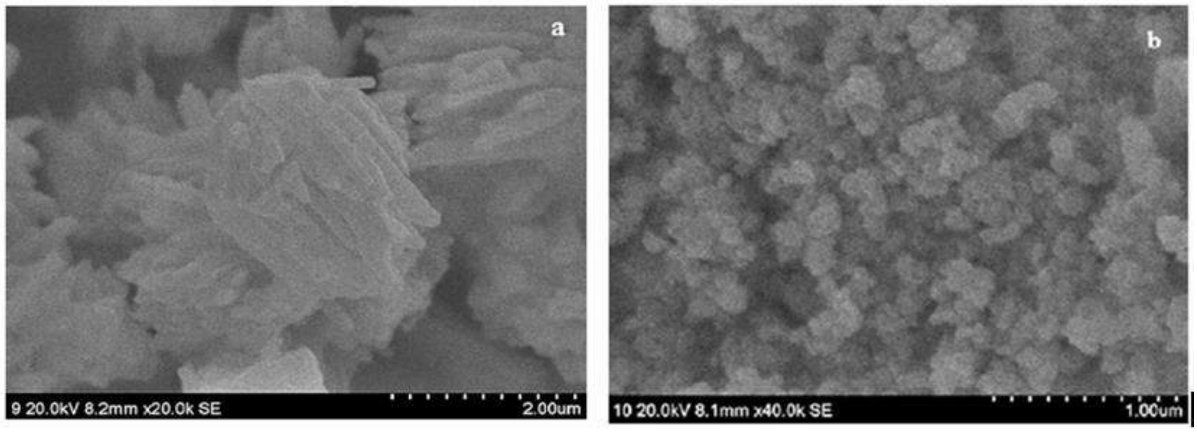
NANOPARTICLES

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 CERIUM 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 CeO2particles synthesized using different precipitant. SEM image of ceria nanopowder for the ammonia water sample is shown in Figure 1a. Large chunks of powder aggregates made up of fi ne 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 cerium oxide nanoparticles varies from 25 to 50 nm.

Figure 2.2 Sem images of cerium oxide



For the blending of cerium oxide nanoparticles in biodiesel, taken a sample of Jatropha biodiesel say 1litre and then 0.05g of cerium 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 cerium 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.

Table 2.1 Properties of biodiesel blend samples

Properties	**Diesel**	**J100**	**J100+50ppmCO**
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^{o}C	17^{o}C	18^{o}C

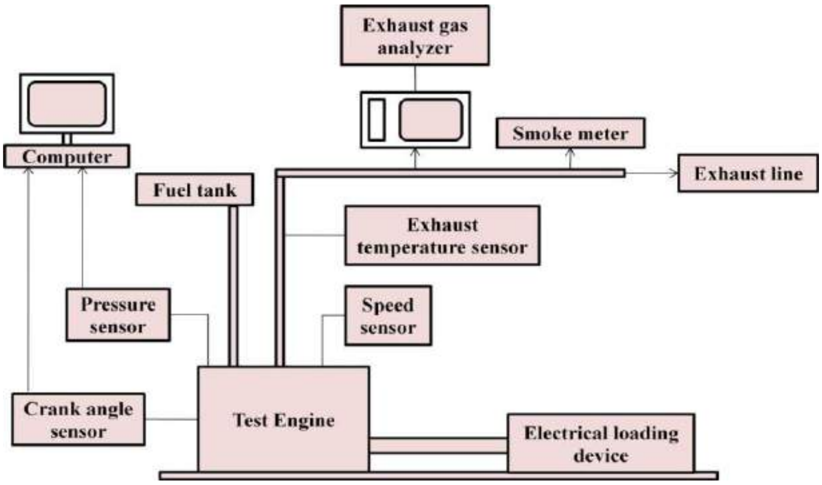
III. EXPERIMENTAL SETUP

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 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.

Table 3.1 Conventional diesel engine specification

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

Figure 3.1 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

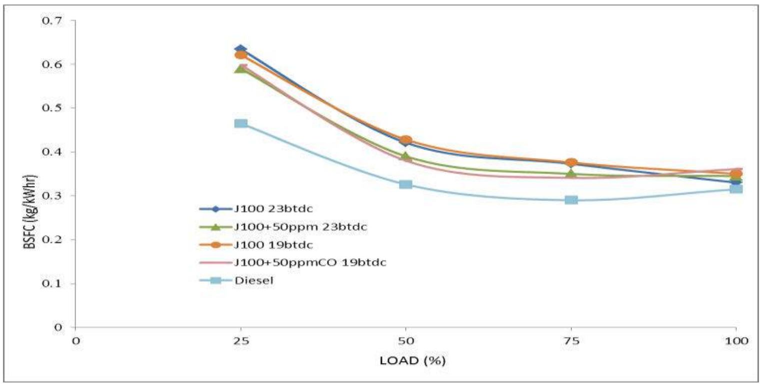
In the present study, the performance, emission, and combustion characteristics of the engine fuelled with diesel, biodiesel (J100) and cerium oxide nanoparticles blended biodiesel (J100+50ppmCO) fuel blends at normal injection timing(23^0btdc) and retarded injection timing(19^0btdc) were compared and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

4.1 ENGINE PERFORMANCE PARAMETERS

BRAKE SPECIFIC FUEL CONSUMPTION

The tests were performed for pure diesel fuel, biodiesel and cerium 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 cerium 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 cerium oxide blended biodiesel is lower than that of biodiesel (J100) for all loads at both normal and retarded injection timing. Cerium 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+50ppmCO at both normal and retard injection timings. This was due to the higher viscosity and lower calorific value of J100 as compared to cerium oxide nanoparticles blended bio diesel. Among the nanoparticles blended bio diesel J100+50ppmCO at 19°btdc has low brake specific fuel consumption.

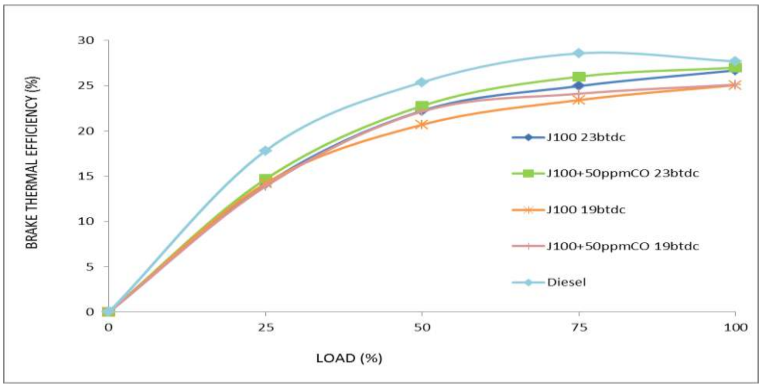
Figure 4.1 Variation of brake specific fuel consumption with percentage of load



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 cerium oxide nanoparticles in biodiesel. The metal oxide nanoparticles present in the biodiesel blend encourage complete combustion, when compared to the sole biodiesel fuel. Cerium 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+50ppmCO with respect to J100 at both normal and retarded injection timings.

Figure 4.2 Variation of brake thermal efficiency with percentage of load

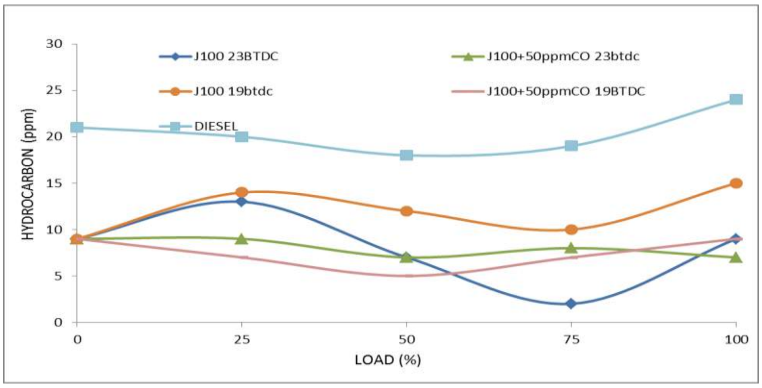


4.2 EMISSION PARAMETERS

HYDROCARBON EMISSIONS

The Figure 4.3 shows the variation of hydrocarbon emissions for 50 ppm level cerium oxide nanoparticles in biodiesel blend with respect to biodiesel. Addition of cerium 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 Cerium 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 cerium oxide nanoparticles with biodiesel. The hydrocarbon emission of J100 decreased on addition of 50ppm cerium oxide nanoparticles by about 20% at normal injection timing. The HC emission of J100+50ppm CO 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.

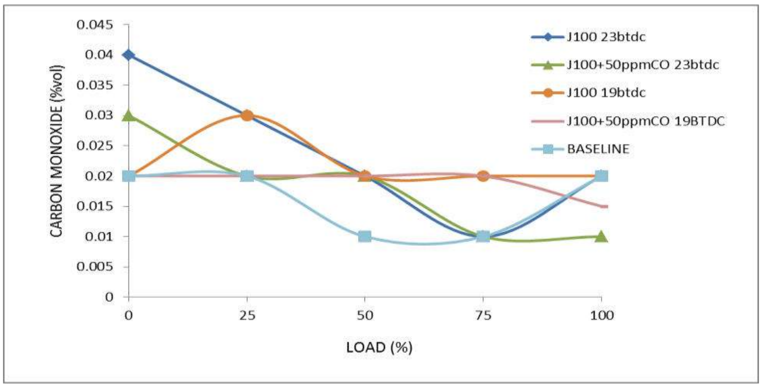
Figure 4.3 Variation of HC emissions with percentage of load



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 cerium 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 cerium oxide blended biodiesel. A maximum decrease of 40% in Carbon monoxide emission was obtained for J100+50ppmCO 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 cerium oxide and nanoparticles blended biodiesel at retarded injection timing is low when compared to baseline diesel. The Carbon monoxide emission of J100+50ppmCO at normal injection timing is low when compared to all other fuel blends at both normal and retarded injection timing.

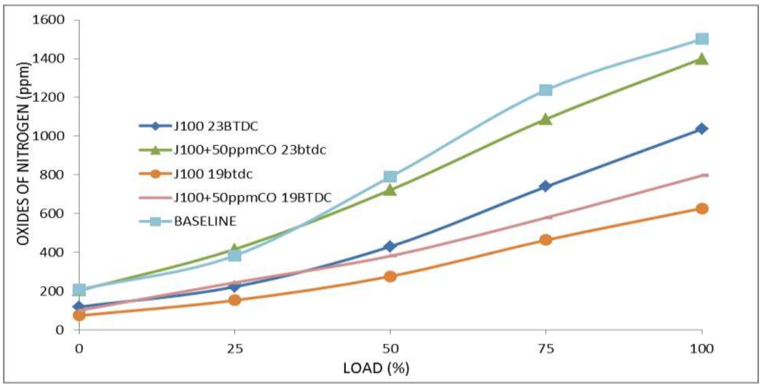
Figure 4.4 Variation of CO emissions with percentage of load



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+25ppmCO 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.

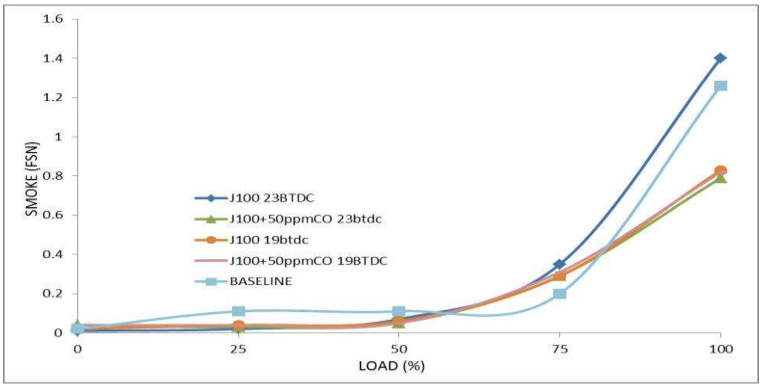
Figure 4.5 Variation of NO_x emissions with percentage of load



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 cerium 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



CONCLUSION

The Present study focus on the influence of cerium 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 cerium 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 cerium oxide nanoparticles.
- The NOx emissions of Cerium oxide nanoparticles blended bio diesel at retarded injection timing drastically reduces when comparing to same fuels at normal injection timing.

- With the use of cerium 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 cerium oxide nanoparticles in biodiesel decreases the HC emissions when comparing with neat diesel andJ100 biodiesel.

NOMENCLATURE

CO	Carbon monoxide
HC	Hydrocarbon
NO_x	Oxides of nitrogen
J100	100%Jatropha oil
J100+50ppmCO	100%Jatropha oil+50ppm cerium oxide nanoparticles
SEM	Scanning electron microscope
ppm	Parts per million
FSN	Filter smoke number

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