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EXPERIMENTAL INVESTIGATION ON SINGLE CYLINDER DIESEL ENGINE FUELLED WITH SOYA BEAN BIODIESEL BLENDS WITH NANO ADDITIVES

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Abstract: Experimental investigations were carried out to determine performance, emission and combustion characteristics of single cylinder diesel engine fuelled with biodiesel blends with the Nano Additives. Biodiesel was prepared from Soya Bean Oil called Soya Bean Methyl Ester (SBME) through Tran's esterification process. The Nano additives (Al_2O_3) were mixed with the fuel blend in the mass fraction of 50 ppm and 100 ppm by means of an ultrasonicator which was set at frequency 40 kHz. The fuel combinations used for the study were neat diesel, diesel with biodiesel blended fuel along with aluminum oxide nanoparticles that are: B20 (80% Diesel + 20% SBME), B30 (70% Diesel+ 30% SBME),B20 $Al_2O_3$50ppm(80% Diesel + 20% SBME + 50 ppm Al_2O_3), B20 Al_2O_3 100 ppm(80% Diesel +20% SBME +100 ppm Al_2O_3), B30 $Al_2O_3$50 (70% Diesel + 30% SBME +50 ppm Al_2O_3),B30$Al_2O_3$100 (70% Diesel + 30% SBME +100ppmAl_2O_3). Investigations were carried out using an experimental setup consisting of single cylinder 4 stroke diesel engine coupled with Eddy Current Dynamometer loading device. Smoke Meter was used for detecting smoke density of each fuel combination. It is observed that Brake Thermal Efficiency of B20 is slightly less than that of B30 but there is considerable increase in volumetric efficiency with the B20 blend; hence out of these combinations B20 can be considered as the best combination with diesel. Other parameters like Brake Specific Fuel Consumption and Air fuel Ratio also yielded good result with B20 combinations. It is observed that smoke reduces in all blends as compared to the neat diesel.

Keywords: Biodiesel, Nanoparticles, Ultrasonic Device, Performance, Emission, IC Engine.

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INTRODUCTION

Now a days, the rapid growth in industrialization has made the transportation sector of a magnificent importance. This transportation sector is dependent upon availability of fossil fuel i.e. petrol and diesel and require it in abundant for its sustainability. Hence there is ever growing need of the fossil fuel and it need to be satisfied. But due to their limited resources and increased demands has made the costs of these fuels increase continuously.

Apart from these higher costs, this fossil fuelled vehicle has led to increase the pollutants such as CO2, NOx, lead, soot, and degrades the environment [2]. In this context, biodiesel has emerged as one of the most potential renewable energy to replace current commercial diesel. Also, it is renewable, biodegradable and non-toxic fuel which can be easily produced through Trans esterification reaction [5]. However, such biodiesel based fuel cannot directly use in diesel engine due to high ignition delay, low cetane number, high brake specific fuel consumption, low calorific value, and low brake thermal efficiency.

It was reported that by addition of nanoparticles to the fuel, the performance and emission characteristics of the diesel engine can be improved [2].

S. Karthikeyan et al [10] conducted experimentation on performance, combustion, emission characteristics using grape seed oil biodiesel blends with Nano additives. And found that the heat release rate increases with addition of cerium oxide Nanoparticles. Addition of cerium oxide Nanoparticles causes rapid combustion and longer ignition delay. C. Syed Aalam et al [5] Experimented on engine performance, exhaust emissions and combustion characteristics of a single cylinder, common rail direct injection (CRDI) system assisted diesel engine. Aluminium oxide Nanoparticles, oxidize the carbon deposits in the engine cylinder leading to reduced fuel consumption and also the results show that the brake thermal efficiency of the CRDI diesel engine is improved by the addition of AONP in the fue. It also enhances the performance and reduces the emission of biodiesel blend used in the diesel engine. S. Manibharathi et al [1] carried out Experimental Investigation of CI Engine Performance by Nano Additive in Biofuel. The reduction of specific energy consumption at part load condition and full load condition by adding Nano additives. Nano additives reduce carbon deposit and wear of diesel engine. A rhodium oxide acts as oxygen which improves performance and reduces the NOx emmsion and UBHC. Nano particles are reduces the energy consumption and improves the thermal efficiency, during combustion the additives release the energy to the fuel. A. Prabhu et al [4] carried out experimental investigation on emission control strategy by adding alumina and cerium oxide nanoparticle in biodiesel. They observed improved brake specific fuel consumption and brake

thermal efficiency for test fuel. Also with the addition of alumina and cerium oxide nanoparticle to neat diesel, lower NOx emission. Prabhu L et al [3] carried out investigation on performance and emission analysis of tio2 nanoparticle as an additive for bio-diesel blends. The carbon monoxide and smoke emission decreases with biodiesel blends when comparing with the neat diesel. The addition of titanium oxide further decreases the CO emission, HC emission and smoke emission when comparing with neat diesel. The present study was aimed to investigate the effect of SBME blended with diesel along with Aluminium nanoparticle on the combustion, performance and emission characteristics of diesel engine. For investigation various blends of Soya bean biodiesel with diesel were taken. The Aluminium nanoparticle was added with various proportions.

MATERIALS AND METHODS

Preparation of Biodiesel:

A potential diesel oil substitute is biodiesel, consisting of methyl esters of fatty acids produced by the trans esterification reaction of triglycerides of vegetable oils with methanol with the help of a catalyst. Trans esterification is one of the most common methods used to reduce oil viscosity in the biodiesel industry is which takes place between a vegetable oil and an alcohol in the presence of a catalyst. Trans esterification 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 [5]. Equipment's required for Trans esterification reaction are beaker, magnetic stirrer and thermometer. Raw materials are soya bean oil, methanol and sodium hydroxide. Soya bean oil was measured to a capacity of 1000 ml and filled into the first beaker. Then, it was stirred at 1000 rpm and the oil was warmed up to 600C. In addition, 3.5 g of sodium hydroxide was dissolved in 200 ml of methanol followed by forceful stirring. This catalyst/alcohol mixture was added to the vegetable oil and stirred vigorously at 1000 rpm for 1 h at 600 C. Crude glycerin, the heavier liquid, was separated at the bottom and methyl ester on the top. After completion, distilled water was sprayed to same volume of methyl ester and allows it to separate for some time. Repeat this procedure until we get the clear water at bottom.

Fig 2.a **Fig 2.b**

Fig2.a: Biodiesel Preparation

Fig2.b: Prepared Biodiesel

Preparation of Fuel Blends:

Nanoparticle blended biodiesel is prepared by mixing Al2O3 nanoparticle with the aid of an ultrasonicator. The ultrasonicator technique is the best suited method to disperse nanoparticle in the base fuel. The nanoparticles are weighted to predefined mass fraction say 50 ppm and disperse in the soya bean biodiesel that is SBME with the aid of ultrasonicator set at a frequency of 40 kHz for 30 min. The same procedure is carried out for the mass fraction of 100ppm to prepare Al2O3 nanoparticle blended biodiesel. Diesel was then added to above solution.

The following formulations were prepared and tested in Engine Test Rig:

B20

B30

B20+50 ppm al2o3

B20+100 ppm al2o3

B30+50 ppm al2o3

B30+100 ppm al2o3

Neat Diesel

Fig 1.2: Nano fluid preparation, Ultrasonicator

Properties of Biodiesel Blend Samples:

Density of biodiesel was measured by standard method and shown in Table 1.3. Density is an important property of biodiesel. Density is mass per unit volume of any liquid at a given temperature. Density measurement was carried out using a Relative density method.

Sr. No.	Fuel	Density (kg/m^3)
1.	Diesel	821
2.	SBME	886
3.	B20	830
4.	B30	833
5.	B20 + 50 ppm Al_2O_3	833
6.	B20 + 100 ppm Al_2O_3	834
7.	B30 + 50 ppm Al_2O_3	835
8.	B30 + 100 ppm Al_2O_3	835.5

Table 1.3: Properties of Diesel and Biodiesel

1.4 Properties of Aluminium Oxide Nanoparticle used:

Sr. No.	Parameters	Specifications
1.	Manufacturer	Nano Shell
2.	Chemical Name	Aluminium Oxide (Alumina)
3.	Average Particle Size	20 nm
4.	Density	3.59 g/cm^2
5.	Thermal Conductivity	12-38 W/mK
6.	Specific Heat	955 J/kg
7.	Purity	99.8
8.	Shape	Spherical

Table 1.4: Details of Al2O3 Nanoparticles

EXPERIMENTAL SETUP AND TEST PROCEDURE:

Experiments were conducted on Kirlosker TV1, four stroke, single cylinder diesel engine connected to eddy current type dynamometer for loading. Schematic of the experimental setup are shown in fig 2. The rated power of the engine was 5.2 kW and engine was operated at 1500 rpm. Specifications of the test engine were given in the table2. The fuel flow rate was measured on a volume basis using a burette and stopwatch. Thermometer and digital display were used to note the exhaust gas temperature. Smoke meter was used for measuring of smoke density. Parameter such as engine speed, fuel flow and smoke were recorded. The performance of engine was evaluated in terms of brake power, brake thermal efficiency, volumetric efficiency, air fuel ratio and BSFC.

Fig. 2: Kirloskar make Single Cylinder Four Stroke Diesel Engine

Sr. No	Parameters	Description
1.	Type of Engine	Kirloskar make single cylinder Four Stroke Diesel Engine
2.	Rated Power	5.2 kW @ 1500 rpm
3.	Cylinder Diameter	87.5 mm
4.	Stroke Length	110 mm
5.	Compression Ratio	17.5 : 1
6.	Cooling	Water cooled
7.	Loading System	Eddy Current Dynamometer
8.	Dynamometer Arm Length	186 mm
9.	Injection Pressure	200 to 205 bar

Table 2: Engine Specification

RESULT AND DISCUSSION:

Brake Specific Fuel Consumption:

Fig.3.A is graph between brake specific fuel consumption (BSFC) and brake power (BP) which illustrate that BSFC goes on decreasing as the load increases. BSFC for diesel is lowest with the

value of 0.253 kg/kWh where as compared to other blends. B20 with the value 0.273 kg/kWh is the second lowest value this is because lower calorific value of these blend as compare to diesel [10]. The difference between this two is only 0.02 kg/kWh which can be considered as negligible and among the other blends B20 is the lowest. Therefor B20 gives better BSFC with BP as the load increase

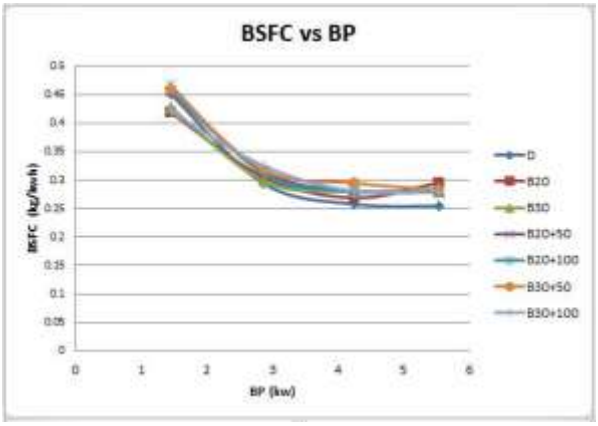

Fig 3.A: BSFC VS BP

Brake Thermal Efficiency:

Fig.3.B is the plot between brake thermal efficiency (BTE) and Brake power (BP). The graph indicates that as the load increases the BTE also increases. At 25% of load, blend B20 gives highest value of Brake Thermal Efficiency as compare to other blend and Diesel. The value is 20.4% for B20 and 18.4% for diesel. At other loads there is no significant variation in Brake Thermal Efficiency and value remains nearly equal.

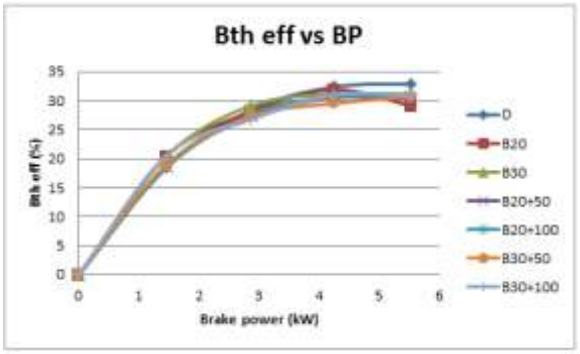

Fig 3.B: Brake Thermal Efficiency Vs Brake Power

Volumetric Efficiency

Fig.3.C. shows the plot between volumetric efficiency and brake power. In this fig one can clearly see the performance of B20 always give better volumetric efficiency as compare to diesel and other blends.

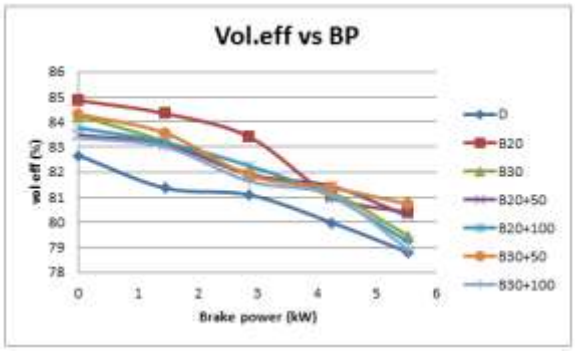

Fig 3.C: Volumetric Eff. Vs Brake Power

Air Fuel Ratio:

Fig. 3.D. is the plot between air fuel ratio and brake power. It was observed that engine air fuel ratio decreases as load and power for diesel, biodiesel blends and diesel biodiesel blends with addition of Nano additives. There is no significant variation in air fuel ratio and the value remains nearly equal. The lowest value of air fuel ratio occurs with the blend B20 + 50 ppm Al2O3 at full load condition and the value is 19.7. At the same load condition air fuel ratio with the bend B20 is 21.2. Hence we can say that air fuel ratio decreases with addition of nanoparticle (Al2O3).

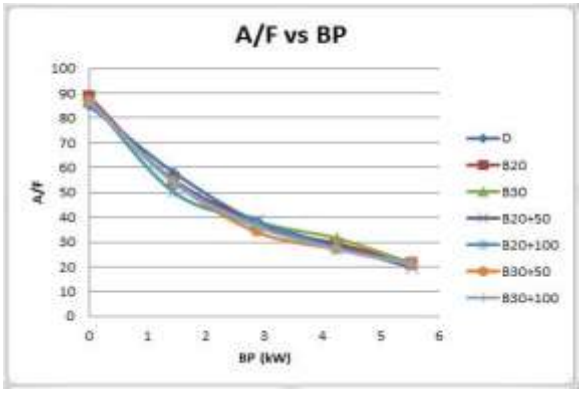

Fig 3.D: A/F Vs Brake Power

Smoke:

Fig. 3.E it is the plot between percentage of smoke and brake power, which shows that smoke increases as the load increases. It is negligible as no load condition. Lowest value smoke occur at B30 as compare to other blends and diesel. The second lowest value of smoke occur at B20. Addition of nanoparticles to the B20 blend further reduces the smoke percentage.

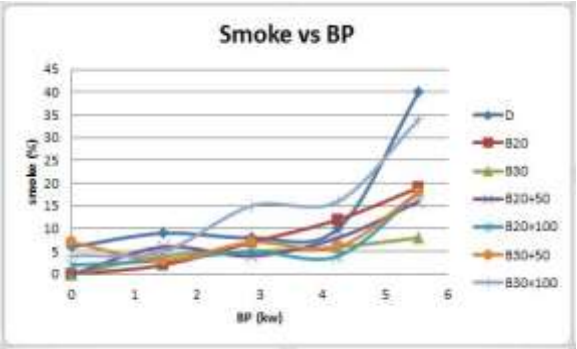

Fig 3.E: Smoke Vs Brake Power

CONCLUSION:

Experimental investigation was done on single cylinder diesel engine fuelled with diesel, biodiesel and its blends with Nano additives. Based on the experimental data following conclusion have been drawn.

At lighter load BSFC is less in case of diesel-biodiesel and its blends with Nano additives compare to that of diesel , but with an increase in load there is little variation.

Brake thermal efficiency increases with increasing load for diesel, biodiesel and it's blends with Nano additives (al2o3).At 25% of load blend B20 gives higher brake thermal efficiency and the value is 20.4%.

Volumetric efficiency is more for all bends at all loads compare to that of Diesel fuel. Among the all blends B20 gives highest value of volumetric efficiency at all load.

Air fuel ratio of the engine decreases with increasing load for diesel, biodiesel and its blends with Nano additives. Lowest value of air fuel ratio at full load condition occurs with the blend B20+50ppm al2o3 and the value is 19.7.

Smoke is less for all blends at all loads compare to that of diesel fuel.

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