Performance and Emission Characteristics of CI Engine When Fuelled with Pongamia Biodiesel and Zinc Oxide Nano Fluid as Additive

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***Abstract*— Diesel engine play important role in the field of commercial transportation. However, the rapid depletion of petroleum products and the stringent regulations lay down by the government to engine manufacturers and consumers to follow the emission norms to save the environment from diesel engine pollution. In this regard, biodiesel derived from various vegetable oils such as pongamia, jatropha, soybean, palm, neem etc. considered as potential alternative fuel for diesel engine. The direct usage of vegetable oil in diesel engine is restricted because of their high viscosity, poor atomization, incomplete combustion and carbon deposition on the fuel injectors. The viscosity of vegetable oil reduced by the process of transesterification by converting vegetable oil into methyl ester or ethyl ester known as biodiesel. The objective of this paper is comparision of performance and emissions of diesel engine with diesel and blending of biodiesel by using nano fluid as additive. Further the work is done on direct injection diesel engine continued by varying the proportion of nano fluid (zinc oxide) with blending of pongamia biodiesel. In this paper we are experimentally calculating the performance characteristics like brake thermal efficiency, specific fuel consumption and emissions like CO, NOx, HC of single cylinder diesel engine with pongamia biodiesel as a fuel by varying nano fluid proportion.**

Keywords*— Diesel, Pongamia biodiesel, Zinc Oxide, performance, and Emissions.

I. INTRODUCTION

Diesel engines are the major source for transportation, marine appilications etc. Due to rapid urbanization and increasing in utilization of technology leads to depletion of petroleum products. This had a serious impact on environmental pollution and there is a need of alternative sources of energy. Biodiesel is one of the potential alternatives to petroleum diesel, as its properties are very comparable to diesel. Moreover, biodiesel is mainly derived from renewable feedstocks like edible, non-edible oils or animal fats.IN recent decades, the main focus is to prepare biodiesel from vegetable oils like cottonseed oil, sunflower oil, coconut oil, jatropha, pongamia. The major differences between Diesel fuel and vegetable oil include, significantly higher viscosity ,lower heating values, higher densities, rise in the stoichiometric fuel/air ratio due to the presence of molecular oxygen and the possibility of thermal cracking at the temperatures encountered by the fuel spray in the diesel engines. Biodiesel is an oxygenated fuel which contains 10-15% oxygen by weight. Also it is said to be sulfur free fuel. These facts leads biodiesel to total combustion and less exhaust emissions than diesel fuel. Using optimized blend of biodiesel and diesel can reduce some significant percentage of the world's dependence on fossil fuels without modification of CI Engine, and also it has environmental benefits. Moreover Additives are an essential part of today's fuels. With the use of fuel additives in the blend of biodiesel and diesel fuelled in CI Engine which furthers more improve performance, combustion, and decrease emission characteristics and also improved fuel properties which enhance the combustion characteristics.

It is observed from the literature that there were efforts to make use of neat biodiesel and to further make it feasible and effective. In the present investigation, Biodiesel was produced from Pongamia oil and investigation on performance and emission characteristics were evaluated using compression ignition engine and also investigated the addition of nano additive on biodiesel effects. In this ZnO nano fluid is taken as additive and based on literature reviews it was planned to investigate the effect of additive on performance by taking proportions like 40ppm,80ppm, and 120ppm.

II. PREPARATION OF BIO-DIESEL

Transesterification is a chemical process of transforming large, branched ,triglyceride molecules of vegetable oils and fats into smaller ,straight chain molecules, almost similar in size to the molecules of the species present in diesel fuel. The process takes place by the reaction of vegetable oil with alcohol in the presence of a catalyst.

In transestirification process Pongamia oil react with methyl alcohol in the presence of catalyst (NaOH) to produce glycerol and fatty acid ester. The methyl alcohol (200ml) and 8 gram of NaOH were taken in a round bottom flask to form sodium methoxide. Then the methoxide solution was mixed with Pongamia oil (100 ml). The mixture was heated to 60°C and held at that temperature with constant speed stirring for 2 hours to form ester. Then it was allowed to cool and settle in a separating flask for 12 hours. Two layers were formed in the separating flask. The bottom layer was glycerol and upper layer was methyl ester. After decantation of glycerol , the methyl ester was washed with distilled water to remove

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excess methanol. The transestirification improved the important fuel properties like specific gravity, viscosity and flash point. The properties of diesel, Pongamia biodiesel and B20 are listed in Table 1.

TABLE 1.FUEL PROPERTIES

Properties	Diesel	Biodiesel	B20
Calorific value (KJ/Kg)	43000	37270	41850
Density(Kg/m³)	850	900	860
Flash point °C	55	144	66
Fire point °C	59	155	72
Kinematic Viscosity(mm²/s)	3.9	4.6	4.1

III. EXPERIMENTAL SETUP

Fig.1: Experimental Setup

The experimental setup consists of a single-cylinder, four-stroke, vertical water cooled, direct injection, natural aspirated, diesel engine connected to water brake dynamometer for loading of the engine. The engine operated at speed 1500 rpm with compression ratio 16.5:1.Fuel consumption of time was measured with help of the burette and stop watch. Thermocouple is used to measure the exhaust gas temperature. Exhaust gas analyzer is used to measure exhaust gases like CO,NOx,HC. Experiments are conducted with pure diesel, diesel blend of pongamia for B20 and with blend of diesel and biodiesel by using ZnO nanofluid as additive. The effects are plotted against brake power(BP). The experimental set up is shown in figure 1.

TABLE 2. ENGINE SPECIFICATION

Type	Single cylinder, four stroke, water cooled internal combustion diesel engine
Capacity	553 cc
Bore x Stroke	80 mm x 110mm
Compression Ratio	16.5:1
Speed	1500RPM
Rated power	5 HP
Make	Kirloskar
Strarting	By hand cranking

IV. RESULTS AND DISCUSSION

A)Brake Thermal Efficiency

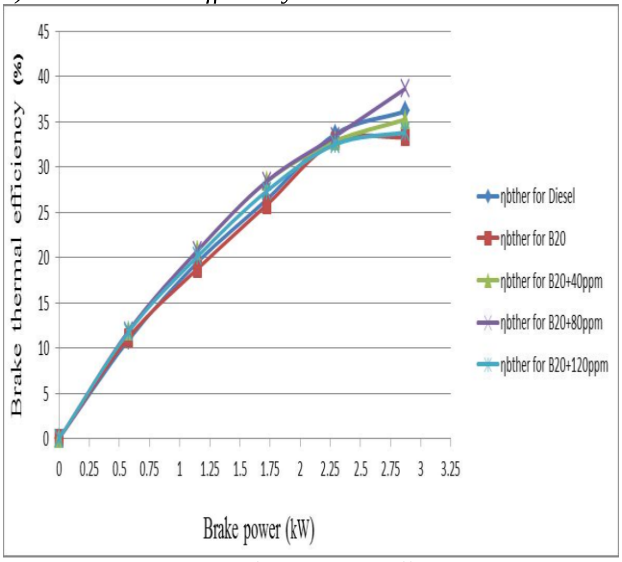

Figure 2. Variation of Brake thermal efficiency with BP

Figure 2 shows the variation of the brake thermal efficiency with brake power for diesel,B20 and B20 with nano fluid additive with different proportions. The thermal efficiency obtained for diesel and B20 are 36.13%, 33.3% respectively at full load. The decrease in thermal efficiency for B20 when compare to diesel is due to lower calorific value, higher viscosity and ineffective utilization of heat energy due to higher molecular weight of methyl ester. whereas for B20 with ZnO for 40ppm, 80ppm and 120ppm are 35.24%,38.63 and 33.82%.The increase in thermal efficiency when B20 is added with additive of 40ppm and 80ppm when compare with B20 and diesel was due to sufficient oxygen content present in nano fluid. Due to this it forms homogeneous mixture and proper combustion takes place and leads to higher thermal efficiency.

B)Brake Specific Fuel Consumption

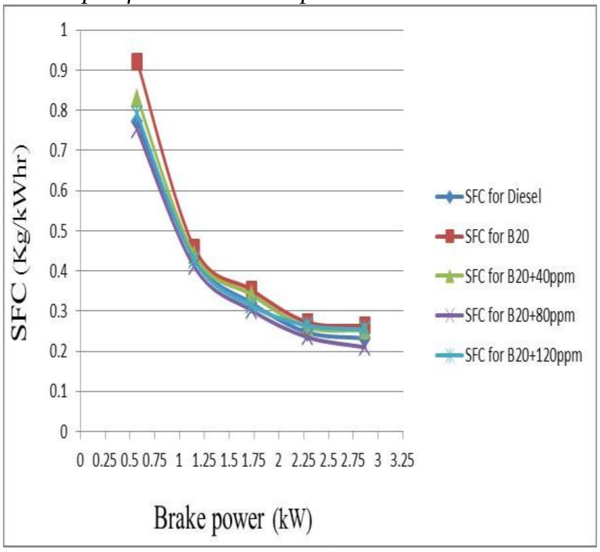

Figure 3. Variation of SFC with BP

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Figure 3 shows the variation of specific fuel consumption with brake power for diesel, B20 and with B20 when added with additives. The SFC values obtained for diesel and B20 are o.232 Kg/kWhr and 0.263 Kg/kWhr respectively, whereas for B20+40ppm,B20+80ppm and B20+120ppm the values are 0.252,0.21 and 0.254.The increase in SFC for B20 is due to high density and viscosity, which leads to effect of mixture formation further leads to slow combustion. When ZnO is used as additive for 80ppm SFC is reduced than diesel at full load , this is due to catalytic chemical oxidation of fuel which leads to improves the combustion of fuel. For 120ppm SFC is increased than diesel due to lean mixture. So for B20+120ppm specific fuel consumption is more than diesel.

EMISSION CHARACTERISTICS

A) Hydrocarbon emission (HC)

Figure 4 depicts the variation of hydrocarbon emission with brake power for diesel, B20 and B20 with nano fuel additive. Hydrocarbon emission was slightly increased for B20 when compare with diesel. The values obtained are 28ppm and 30ppm.the increase in emission for B20 at full load is due to enough oxygen is not present and it forms rich micture.so incomplete combustion takes place hence increase in emissions. When compared B20 mixed with

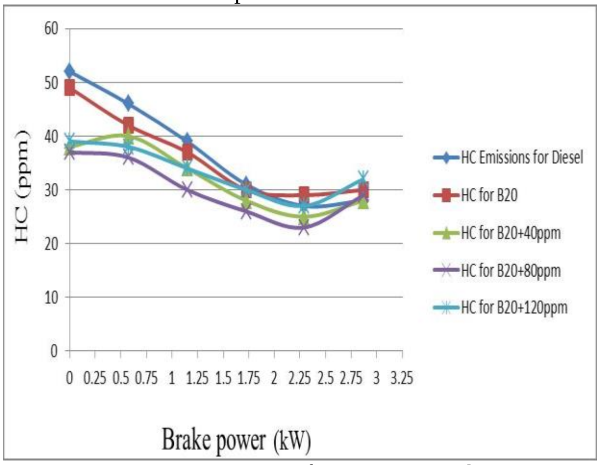

Figure 4. Variation of HC emissions with BP

nano fluid for B20+80ppm yields minimum emissions than diesel. The reason is, due to presence of oxygen content in additive that makes homogeneous mixture and results in complete combustion. Thus reduction of hydrocarbon emissions are observed for B20+80ppm.

B) Carbon monoxide emission (CO)

Figure 5. illustrates the variations of carbon monoxide emissions with brake power. Generally CO emissions occur due to fuel rich combustion and insufficient time. The emission values obtained for diesel and B20 at full load condition are 0.08% and 0.07%.The increase in CO emissions for diesel are due to lack of oxygen or due to engine running in too rich condition. The decrease in emission level for B20 is due to presence of 10 to 11% of oxygen content in biodiesel. By adding additives for B20+80ppm has obtained lower emission when compared to diesel. The values obtained are 0.06%, 0.05% and 0.09% for B20+40ppm,B20+80ppm and B20+120ppm.The emissions reduced at 40ppm and 80ppm at full load due to the oxygen present in additives and forms stoichiometric mixture and complete combustion takes place with less emissions of CO.

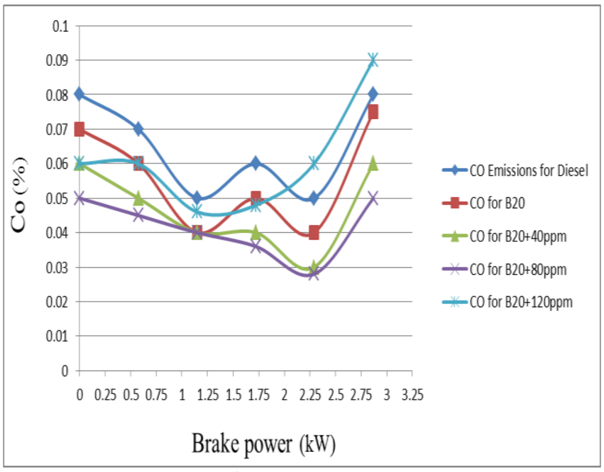

Figure 5. Variation of CO emissions with BP

C) Nitrogen oxide emission (NOx)

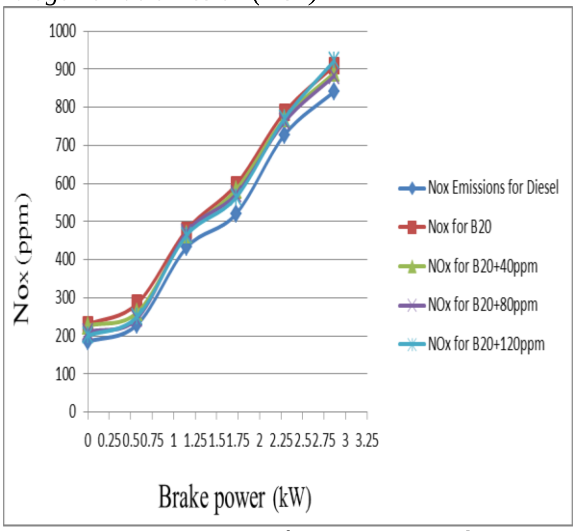

Figure 6. Variation of NOx emissions with BP

The differences of NOx emission for diesel, Pongamia biodiesel and Pongamia biodiesel with Nano-fuel additives with brake power shown in figure 6. Mostly NOx emissions forms due to higher combustion temperature and other factors like injection timing, lack of oxygen and combustion quality. The obtained NOx emissions for diesel B20,B20+40ppm,B20+80ppm and B20+120ppm are 842ppm,910ppm,891ppm,883ppm and 923ppm.The NOx emission is found to be minimum for B20+80ppm when compared with other biodiesel nano-fuel additives and higher than diesel. This is due to change in the combustion temperatures.

D) Exhaust gas temperature

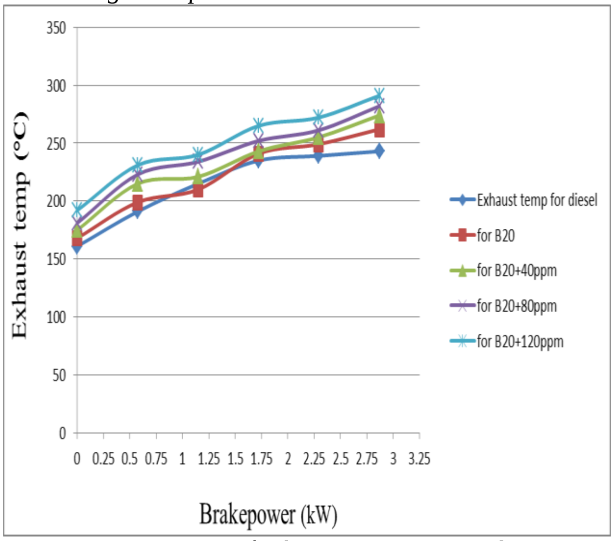

Figure 7. Variation of Exhaust gas temperature with BP

From the graph the variation of exhaust gas temperature with brake power for diesel, B20 and for biodiesel with nano fuel additives are obtained as 243°C,262°C,274°C,282°C and 291°C.The temperature values increased for all B20,B20+40ppm,B20+80ppm and B20+120ppm when compare with diesel. Due to combustion rate increases at full load ,the exhaust gas temperature obtained is also higher at full load.

V. CONCLUSION

The experiments were conducted with Pongamia biodiesel and ZnO as a nano-fluid has been studied and investigated the performance and emission characteristics. The following conclusions based on the experiment are,

- B20 is having lower efficiency and higher energy consumption due to this results in lower heat value. The addition of nano fuel additives there is a significant increase in thermal efficiency compare to biodiesel without additives.
- The brake thermal efficiency for B20+80ppm increased by about 2.06% when compared with diesel at full load.
- The reduction in CO emission by using B20+80ppm has observed when compare with diesel. The CO emissions reduced by 25% when compared with diesel.
- The HC emissions are obtained minimum for B20+80ppm when compared with diesel and other biodiesel nano-fuel additives.
- NOx emissions are increased for all biodiesel nano fuel additives and for B20 when compare with diesel at full load. For B20+80ppm the emission value obtained is minimum when compare with B20,B20+40ppm and B20+120ppm and increased when compare with diesel. This is due to higher combustion temperature.

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