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Experimental Study on Performance and Emission Characteristic of Diesel Engine using Sunflower oil Biodiesel Blends

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K E Y W O R D S

Diesel, Biodiesel, performance , emission characteristics.

A B S T R A C T

Biodiesel fuel is a liquid biofuel produced by chemical process form new and used phytogenic oils, animal fats. Biodiesel fuels can be utilization alone or mixing with the pure diesel at different proportion. In the present work a diesel engine type (FIAT) , four cylinder, variable speed, direct injection was operated by sunflower oil methyl ester , biodiesel at different blend ratio . five different ratio of biodiesel blends 10%, 20%, 30%, 40%, and 50% by volume is used in this study and compared with using of pure diesel at variable loads and variable engine speed. The effect of biodiesel additive to pure diesel on the performance and emission characteristics. Adjust the engine speed at 1100 rpm by means of the engine tachometer and digital tachometer, and reduce the load gradually until the engine speed increased to 1900 rpm automatically by increments of 200 rpm. The BSFC for B20 It seems less than the other ratio of biodiesel blends, and the BTE of biodiesel blends is lower than the pure diesel but the B20 having high BTE in comparison with the other biodiesel- diesel mixtures. the UHC and CO emission for B20 is less than the biodiesel blends and pure diesel, but the NOX emission for B20 is lower than the other biodiesel blends and higher than pure diesel. The present work shows the B20 relatively is a better performance and combustion characteristic than that biodiesel blends ratio .

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1. Introduction

Biodiesel has already been commercialized in the transport sector and can be used in diesel engine with no modification [1]. The biodiesel fuel can be mixing with the conventional diesel fuel are environment friendly and their use in diesel engine because of the biodiesel fuel is a lower exhaust emission characteristic as compared with the conventional diesel fuel [2]. The biodiesel fuel used due to reductions in petroleum consumption, unburned hydrocarbon, and carbon monoxide emissions [3]. Biodiesel itself is a type of biofuel made by combining animal fat or vegetable oil can be used alone called B100 or mixed with the pure diesel, such as B20%+ D 80% called B20 [4] produced from animal fats, or vegetable oils. The physical properties of the biodiesel are similar to those of petroleum diesel, but it is cleaner burning alternative [5-6]. The advantage of biodiesel is that can be using in a diesel engine without any modification, and lower toxicity compared with the diesel fuel. The disadvantages of biodiesel fuel are higher fuel consumption and increasing in nitrous dioxide ($NO_{X)\ emission}$ than diesel fuel [7].

The current work is aiming at the comparative assessment of performance, emission and combustion characteristics of a four-cylinder diesel engine alternatively fuelled with biodiesel and its 10%, 20%,30%, 40% and 50% blend with pure diesel. Biodiesel have a higher lubricant characteristic as compared with the diesel fuel therefore increased the life span of the engine, and safe for handle and store because of high flash point, in addition the biodiesel fuel contained a high oxygen percentage that enhanced a complete combustion inside the combustion chamber. The biodiesel is the ideal fuel to uses in the heavily polluted cities. Therefore, the biodiesel fuel is a safe substitute for transmission and storage. Durve et al. [8] Carried out an experimental study include Comparing three proportion of biodiesel mixing with the neat diesel, on the engine performance and exhaust emission characteristic. the ratio of biodiesel addition on the neat diesel blends is B10, B15 and B20. the results of the experiment convince that the rises of biodiesel ratio caused high fuel consumption. Increases the NO_x emission with increases the biodiesel blend ratio, and the UHC and CO emission reduced with increases the biodiesel blend ratio. Ramesha et al. [9] experimental work, test the utilization of fish oil biodiesel on performance and exhaust emission characteristic of compression ignition engine. the experimental study results showed that the B20 is the better biodiesel blend concerning the engine performance and exhaust emission characteristic. Vijayakumar et al. [10] carried out an experimental study the effect of mahua methyl ester blends with pure diesel on the engine performance and exhaust emission characteristic. The mahua methyl ester biodiesel blend with pure diesel at different ratio 20% , 40% , 60% , 80% and 100% . the experimental results showed that the 20% mahua methyl ester blend with pure diesel (20MEOM) is the best blend ratio as compared with the other blends in regard to performance and emission characteristic. Vaneet Bhardwaj et al. [11] achieved an experimental study the effect of waste cotton seed oil biodiesel at different blend ratio with pure diesel on engine performance. The calorific value of waste cotton seed oil biodiesel is less than the pure diesel, the experimental results show the B10 blends is the best performance characteristic than the other waste cotton seed biodiesel blends B15 and B20 when fueled in a diesel engine.

Liaquate et al. [12] carried out an experimental analysis the effect of the coconut biodiesel at different blends ratio with the diesel on performance and emission characteristic using direct fuel injection engine. Three fuel samples used in this study D 100(100% pure diesel), B5(Biodiesel 5%+diesel95%) and B15(Biodiesel 15%+ diesel 85%) without modification design on the diesel engine. The experimental results showed all that biodiesel blends ratio is lower brake power and engine torque as well as higher fuel consumption as compared with the pure diesel at all engine speed. the biodiesel blends distinguished with lower UH, CO, and increased the NO_X and CO_2 emissions as compared with the pure diesel. Chaichan [13] Studied the engine performance and exhaust emission characteristic for direct injection compression ignition engine. in this work the biodiesel using produced from sunflower oil by transesterification process. two different biodiesel blend ratio used in this work and compared with pure diesel fuel. The experimental results showed that the biodiesel blends is lower (BTE) and higher (BSFC) as compared with pure diesel. The exhaust emission such as CO, UHC and CO_2 decreased with the biodiesel blends and increased the NO_X emission as compared with pure diesel.

Khan et all. [14] investigated study on the impact of biodiesel fuel on engine performance and exhaust emission characteristic and compared with pure diesel. The experimental results showed that the biodiesel fuel is a better lubricity and less pollutant emission as compared with pure diesel.

2. Experimental setup and methodology

The experimental investigation was carried out on (FIAT) diesel engine four cylinder, four stroke, water cooled, natural aspirated and compression ratio of 17:1. The Table 1 presents the specifications of the diesel engine. The image of diesel engine of the experimental setup used is shown in Figure 1. The diesel engine is coupled with the hydraulic dynamometer to measuring the brake torque. Applying the full load on the engine by the hydraulic dynamometer, Adjust the engine speed at 1100 rpm by means of the engine tachometer and digital tachometer, and reduce the load gradually until the engine speed increased to 1900 rpm automatically by increments of 200 rpm. The exhaust gas temperature is measured by using a thermocouple type (J) and digital reader. The measuring rod connected to the outer pipe of the exhaust manifold by the prop instrument to measure the exhaust temperature as shown in Figure 2. The Exhaust gas analyzer type (HG-540/550) that used to the analysis and measure of the emissions of the exhaust gases, as shown in the Figure 3. The exhaust gas analyzer detected the NO_X, HC, CO, and CO_2 concentration. Figure 1: the FIAT Diesel engine with dynamomete

Table 1: Engine specification.

Engine parameter	Value
Engine type	FIAT diesel engine 4 cylinder, 4 stroke
Engine model	TD 313 Diesel engine REG
Displacement volume	3666 cm^3
Combustion type	Direct injection, water cooled , natural aspirated
Valve per cylinder	(2)
Bore	100 mm
Stroke	110 mm
Compression ratio	17:1
Fuel injection pump	Unit pump 26 mm diameter plunger
Fuel injection nozzle	Nozzle hole diameter (0.48mm) . Spray angle 160^o. Nozzle opening pressure 40 mpa

Figure 1: The FIAT Diesel engine with dynamomete

Figure 2 : Exhaust gas temperature.

Figure 3: Gas analyzer measurement.

3. Preparation Biodiesel blends.

The biodiesel blends were prepared for the experiments by mixing the two fuels volumetrically . the biodiesel fuel is mixed with the diesel fuel at five ratio B10 (biodiesel 10% +diesel 90%) , B20 (biodiesel20%+diesel80%),B30(biodiesel30%+diesel70%),B40(biodiesel40%+diesel60%)andB50(biodiesel50%+diesel50%). The diesl engine operated with the biodiesel blends and cmpared with the pure diesel .

The engine performance parameter such as brake thermalefficiency (BTE),and brake specific fuel consumption (BSFC) and exhaust emission characteristic like unburnt hydrocarbon (UHC) , nitrogen oxides (NO_X) and carbon monoxide (CO) , all these parameters were measured and analyzed. The physic- chemical properties of the pure diesel , biodiesel and blends are listed in Tables 2.and 3.

Table 2: The physic- chemical properties of biodiesel and pure diesel.

Properties	Blending biodiesel ratio				
	B10	B20	B30	B40	B50
Viscosity Cs 27 ^{0} C	Blending	3.224	3.446	3.668	3.889
Density kg/m^3	biodiesel	860.6	869	874.6	874
Flash&FirePoint ^{0} C	ratio	81-86	83-88	85-91	89-96
Cetane number		53.4	54.7	55.8	56.9
Calorific value kJ/kg		43431.99	42653.99	41633.19	40223.09

Table 3: The peoperties of biodiesel blends.

Properties	Blending biodiesel ratio				
	B10	B20	B30	B40	B50
Viscosity Cs 27 ^{0} C	3.002	3.224	3.446	3.668	3.889
Density kg/m^3	855.2	860.6	869	874.6	874
Flash&FirePoint ^{0} C	79-83	81-86	83-88	85-91	89-96
Cetane number	52.6	53.4	54.7	55.8	56.9
Calorific value kJ/kg	44647.99	43431.99	42653.99	41633.19	40223.09

4. Results and discusstion

I. specific fuel consumption.

Figure 4 illustrates the variation of Brake specific fuel consumption (BSFC) with increased the engine speed (rpm) and reduced the load, for various fuel blends. the Brake specific fuel consumption for the biodiesel –diesel blends seems to be high than the pure diesel , this because of decrease the calorific value and increase viscosity of the biodiesel blends as compared with the pure diesel ,This caused a large volume of fuel droplets after atomization which lead unproperly mixing with the air[9].The brake specific fuel consumption (BSFC) for the (B20% + D80%) B20 is seems to be lower than B10 , B30, B40 and B50 . A suitable oxygen content and density that creates a complete combustion in (B20% +D80%) blends [7]. The increase in the specific fuel consumption (bsfc) is about (5.85%, 7.48% , 10.55 % , 14.3% , and 16.5) for (B20 , B10 , B30 , B40 and B50) ratios as compared with pure diesel at full load 80 kg and engine speed 1100 rpm.This results are in agreement with [7-8].

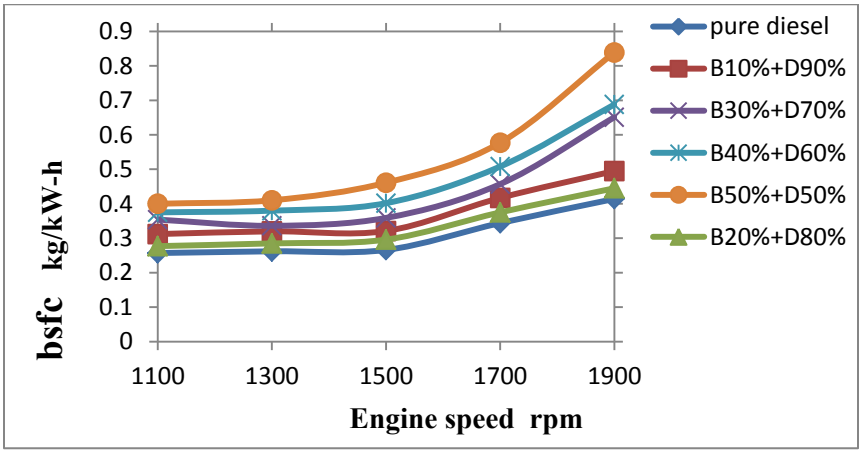

Figure 4: Change the BSFC with engine speed rpm.

II. Brake thermal efficiency.

Figure 5. reveals the variation of Brake thermal efficiency (BTE) with engine speed for the pure diesel , B10 ,B20 , B30 , B40 , and B50.It is evident from figure that the pure diesel is having higher brake thermal efficiency (BTE) than the biodiesel blends because of the higher viscosity and lower calorific value of biodiesel as compared with the pure diesel. The brake thermal efficiency of the B20 blends is a better performance as compared with the other blends (B10 ,B30.B40 and B50). This is because of sufficient oxygen content that make a better combustion even though the viscosity has no effect on the performance [3]. However the brake thermal efficiency (BTE)for B20 is less than that of pure diesel. The decreases of the brake thermal efficiency is about (2.6% , 3.44% , 5.1% , 7.3% and 8.6%) for (B20 , B10 , B30 , B40 ,and B50) ratios as compared with the pure diesel at full load 80kg and low speed engine 1100 rpm.

III. Exhaust gas temperature.

Figure 6 elucidates the variation of exhaust gas temperature (EGT) with increasing of the engine speed from 1100 rpm to 1900 rpm and reducing the loads. It is seen the exhaust gas temperature (EGT) decreases with increases the engine speed for pure diesel and all ratio of biodiesel blends . Higher exhaust temperature obtained when increases the ratio of biodiesel blends because of increased the ignition delay and therefore will \advance the combustion through the expansion stroke which makes higher exhaust temperature[11].

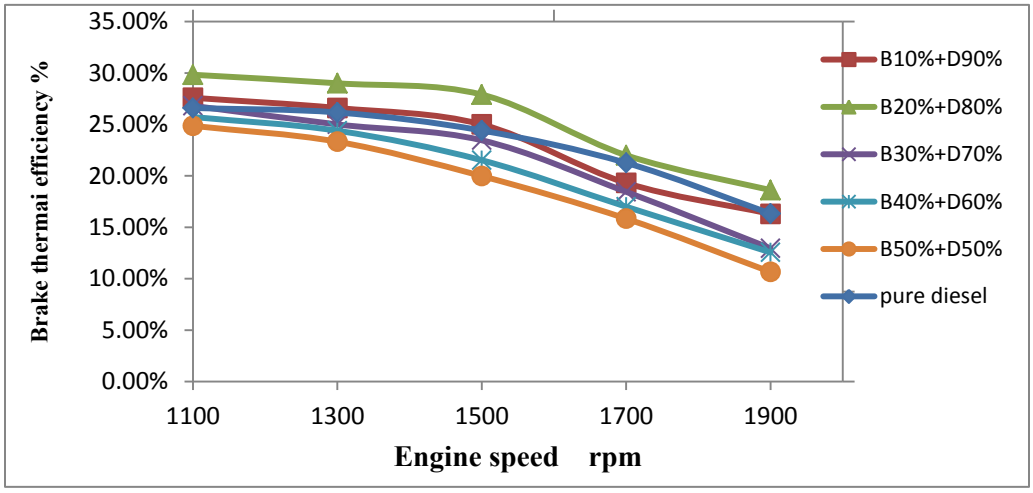

Figure 5 : Variation BSFC with engine speed

But it is observed the B20 is less exhaust temperature as compared with the other blends of biodiesel this due to complete combustion through the early part of expansion stroke. And the B20 have a better content of oxygen to create a better and complete combustion as compared with the other ratio of bio diesel blends.This results are in agreement with [15].

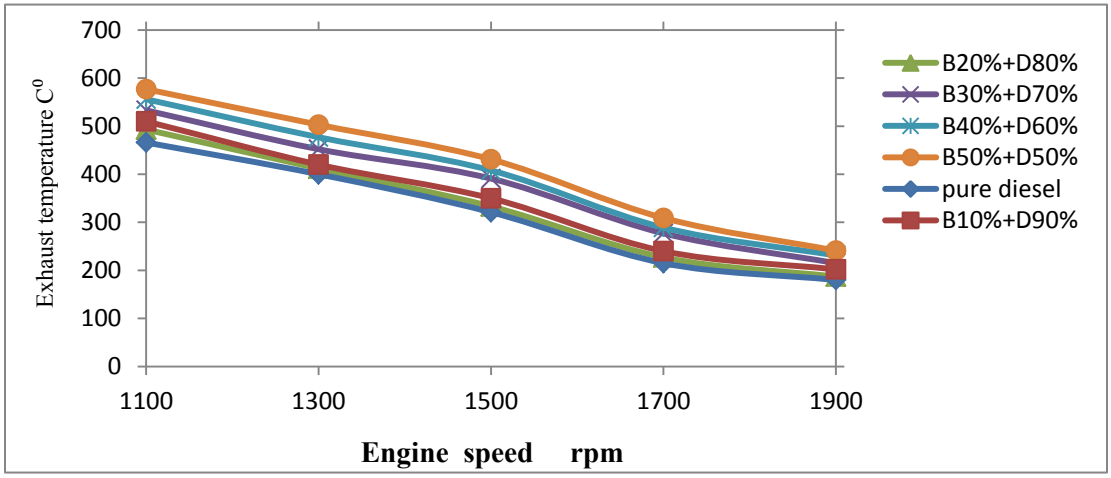

Figure 6 : Variation of exhaut temperature with engine speed

IV. The unburnt hydrocarbon UHC emissions.

The Figure7 manifests the variation of unburnt hydrocarbons (UBHC) emission with variation the engine speed and the loads. It is seems that the Unburnt hydrocarbons Emissions characteristic for all ratio of biodiesel blends is less than the pure diesel fuel, and the B20 is less than the biodiesel blends and pure diesel fuel. This is because of the B20 have a presence sufficient oxygen to make a complete combustion that leads to decreases the unburnt hydrocarbons (UBHC) emissions[16]. The (UBHC) for B20 at full loads is less than the (B0 , B10 , B30 , B40 , and B50)which is (25.4% , 19.6% , 13.7% , 7.8% and 3.9%) respectively at full load 80 kg and low engine speed 1100 rpm.

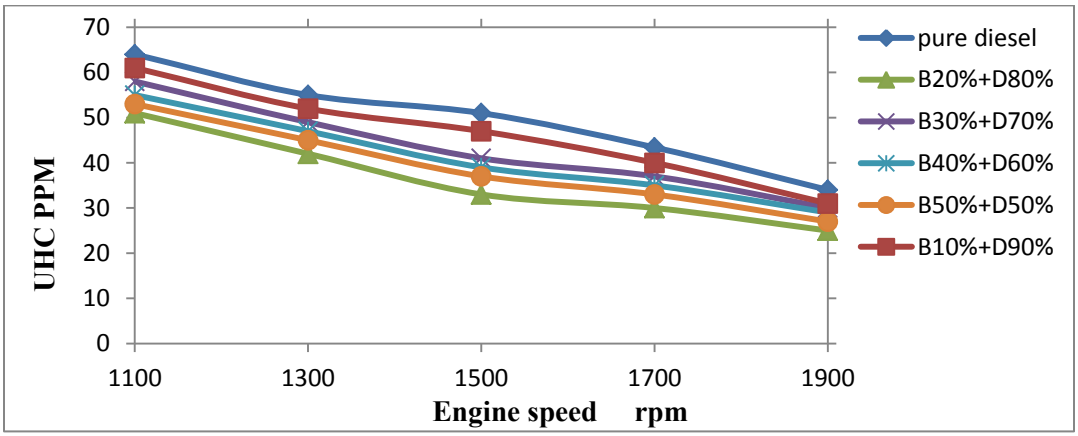

Figure 7 : Variation of UHC with engine speed

V. The Nitrogen oxides NOX emission

The Figure 8 exhibits the variation of Nitrogen Oxide (NO_x) Emission for pure diesel and different ratio of biodiesel blends with the diesel fuel at different engine speed and load. It is observed that the NOx emission deceased with decrease the load and increase the engine speed for all fuels this due to decrease the temperature of combustion chamber [8], [15]. The Nitrogen oxide (NO_x) Emission for pure diesel seems to be less than the other ratio of biodiesel blends , and the (NO_x) Emission for B20 is found less than the other ratio of biodiesel blends. the (NO_x) Emission increased at full load for (B0 , B20 , B10 , B30 , B40 , and B50) about (1045 , 1088 , 1133 , 1188 , 1231 , and 1254) ppm respectively at full load 80 kg and low speed engine 1100 rpm.This results are in agreement with [8], [15].

VI. The carbon monoxide CO emissions.

The Figure 9 demonstrates the variation of carbon monoxide (CO) with increases the engine speed and decreases the engine loads. The carbon monoxide is a toxic gas product from all hydrocarbons combustion is also decreasing with increasing the oxygen content of the fuel blends . It is observed that the carbon monoxide (CO) emission for all ratio of biodiesel-diesel blends at**.** full load is less than the pure diesel fuel .the (CO) emissions for B20 at full load is lower than the all biodiesel blends , these decreasing indication for more complete combustion of the biodiesel blends[9]. The CO emission for B20 at full load is lower than the fuels(B0 , B10 B30 , B40 , and B50) is by (33% , 26.66%, 24.13% , 12% and 8.334%) respectively at full load and low speed engine 1100 rpm.

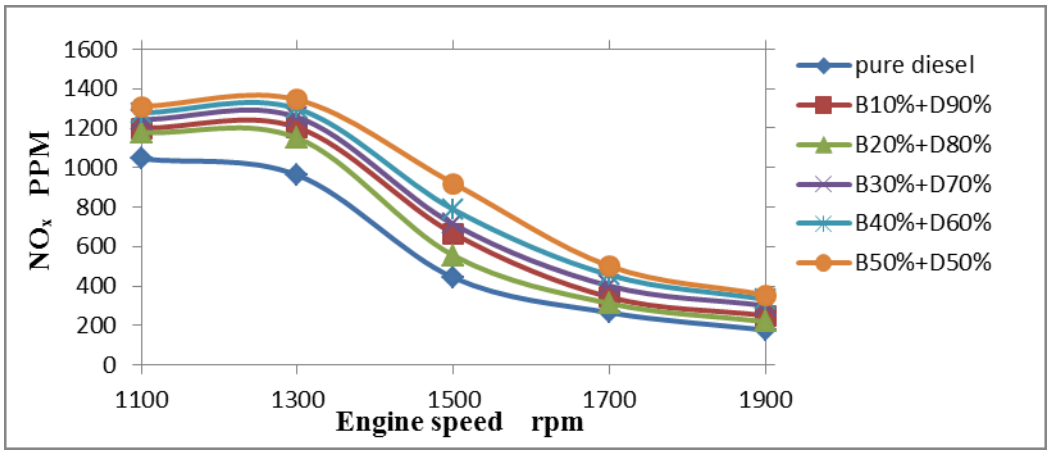

Figure 8 : Variation NO_X emission with engine speed

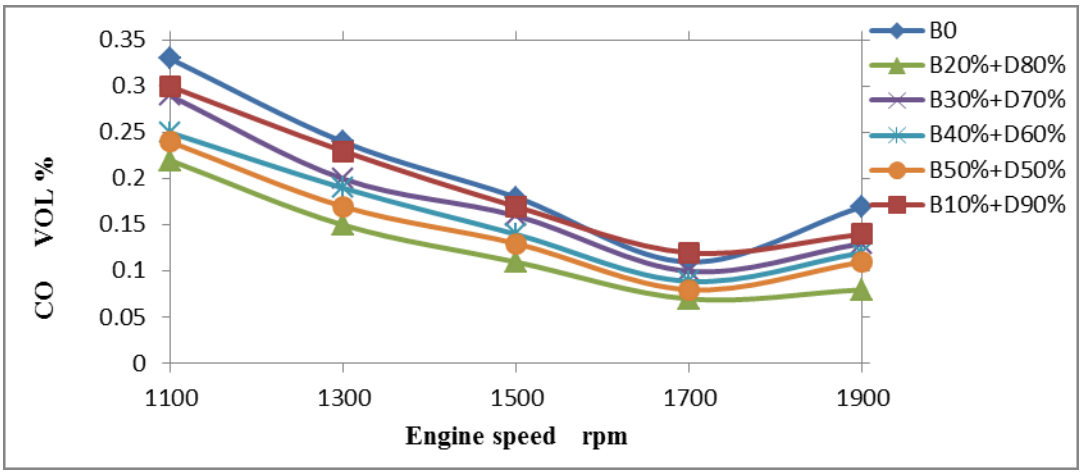

Figure 9 : Variation CO emission with engine speed.

5. Conclusions

The diesel engine performed satisfactorily on biodiesel , so that the biodieselcan be used as an alternative fuel in existing diesel engine without any hardware modification . It could be concluded that the 20% percent blend of biodiesel with pure diesel fuel can be observed is the best blend in regard to performance and exhaust emission characteristics as compared to all other blends . Also biodiesel reduces the environmental impacts of generators and transporaion. Reduces the dependence on crude oil Hence the biodiesel fuel may be used as alternative fuel than the petroleum fuels in the compression ignition engine because of its low emission characteristics and equivalent energy.

Nomenclature

EGT- Exhaust Gas Temperature.

NO_X – Nitrogen Oxide.

UHC - Unburned Hydrocarbon.

CO - Carbon Monoxide.

CO_2- Carbon Dioxide.

ppm – part per million .

BSFC- Brake Specific Fuel Consumption.

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