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PERFORMANCE AND EMISSIONS OF DIESEL ENGINE FUELLED WITH ETHANOL AND PALM OIL METHYL ESTER

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Abstract - In current day the biodiesel is so extensively studied, but even today the question of which blend of methyl ester-diesel is best suitable for current diesel engine is yet remains unanswered. Comparing to laboratory testing and Actual testing where transport vehicles are studied on street, the only operating parameters studied are load and speed which define engine efficiency and fuel utilization for a particular length. In this paper, spotlight is focused to explain experimentally the performance and exhaust emission characteristics of a Direct Injection –Compression Ignition engine when fuelled with Palm oil methyl ester biodiesel (PB10,P B20,PB30) addition of ethanol (E5% and E10%) over the various loading conditions on the engine. The observations made are lesser Carbon Monoxide emissions and Exhaust Gas temperatures reduced within increase of doping of ethanol content in Blends of Methyl Ester and its blends.

Key Words: Palm oil, biodiesel, Fatty Acid Methyl ester, ethanol, performance and emissions

1.INTRODUCTION

Biodiesel is gaining more and more attention day by day because of its properties that resemble diesel and compatibility with petroleum-based diesel fuelled engines Biodiesel can be produced through transesterification of renewable resources, such as vegetable oils or animal fats that use alkaline, acid, or enzymes as catalyzes. Basically FAME/Biodiesel is an "On Farm Fuel" where farmer can grow his own resource, convert to biodiesel and use in agricultural sets itself without the need of any diesel for blending [1]. In today's world the challenge to lift the use of biodiesel/alternative fuels has increased to high extent, which mainly focuses fuels which can be readily used engines without major changes in engine design. Biodiesel/Methyl/Ethyl Esters who lack in optimum thermo-physical properties mainly calorific Value, viscosity, fire point etc which restricts the combustion scenario and fuel pump lines of automobile. Alcohol Esters/Bio Diesel has good oxygen content in the blend which helps in better combustion.. Comparing to performance biodiesel excels and fails in emissions in NOx. In current paper highlights to fact that adulteration of ethanol in Methyl ester and its blends which usually results in lesser carbon monoxide emissions which is positive point. B. Deepanraj et al [8] found that the lower blends of biodiesel increased the brake thermal efficiency and reduced the fuel consumption. Biodiesel blends produce lower engine emissions than diesel. From the result, it has been established that 20-40% of palm oil biodiesel can be use as a substitute for diesel without any engine modifications. Deepali Bharti et.al. [9] Evaluated the effect of using n-butanol (normal butanol) in conventional diesel fuel biodiesel blends on the engine performance parameter of a single cylinder direct injection compression ignition engine with the engine working at different three engine loads. B20 (20% biodiesel and 80% diesel in volume) was prepared, and then n-butanol was added to b20 at a volume percent of 5%, 10%,15% and 20%. The performance parameters evaluated include thermal efficiency, brake specific fuel consumption (bsfc), brake specific energy consumption (bsec). They observed an enhancement of combustion, fc, bsfc, efficiency and the overall performance of the engine. G. Prommes Kwanchareon et al; [5] investigated solubility of a diesel- biodiesel- ethanol blend, its properties and its emission characteristics from diesel engine. Also the blended fuel properties

were close to the standard diesel except flash point. The CO and HC emissions reduced significantly at high engine load, whereas NOx emissions increased compared to those of diesel. The investigation focussed to the point that diesel-biodiesel-ethanol blends reduce CO, HC, PM, Smoke emissions and increase NOx emissions compared with the diesel fuel. There is a little research on the use of rice bran oil biodiesel in diesel-biodiesel-ethanol blends for diesel engines. The performance and emission characteristics of the biodiesel blended up to 20% were close to that of diesel fuel [4, 5]. H.B.Parikh et.al [6] Experimented engine performance and emission characteristic studies on selected fuel blends at different load conditions. Property point of view density and pour point of all the fuel blends are under the standard limits for diesel fuel. Heat of combustion of all blends is found to be lower than that of diesel fuel alone. D70B20E10 give lower CO and HC emission and slightly higher thermal efficiency than other blends. Venkata Subbaiah et al; [2] found that the brake thermal efficiency was observed with 15% ethanol in diesel-biodiesel-ethanol blends was highest. The exhaust gas temperature coming from the engine retarded with the adulteration percentage of ethanol in diesel-biodiesel-ethanol blends. The Carbon monoxide and smoke emissions reduced significantly with higher percentage of ethanol in diesel-biodiesel-ethanol blends. On the contrary, Hydrocarbons emission and NOx emission increased with the increase of ethanol percentage in diesel-biodiesel-ethanol blends. In the present investigation the performance and emission characteristics of a diesel engine were studied by using 10% rice bran oil biodiesel as an additive in the diesel-biodiesel-ethanol blends and compared with that of the diesel fuel. Both fluids ethanol and mineral diesel fuel do not form a single phase in nature. Doping percentage of Ethanol affects the thermo-physical properties mainly viscosity calorific value, viscosity. Also properties like volatility and stability are also disturbed by addition of ethanol. C.Srinidhi et.al [7] observed on the use of Waste vegetable oil bio diesel pointing to the addition of ethanol providing a better thermal efficiency with the regular blend of biodiesel and diesel where in almost a shift in increase of 12%. The b.s.f.c pushed up to higher value, increasing the consumption of fuel for per kW power output under load conditions. Also the carbon monoxide emissions reduced on addition of ethanol in the blends. The use of biofuels increases the combustion efficiency and lowers CO, HC emissions but increase the cylinder combustions chamber temperature there by increasing the formation of nitrous oxides. A proper emulsifier and co-solvent were used for avoiding the phase separation by lowering the surface tension and co-solvent helped in solvency for the pure solvent. In practice, biodiesel premises increase of ethanol-blended fuel making the mixture more stable. Primarily ethanol helps in diesel engines in improving of engine ignition as almost all alcohols have lesser flash point in comparison.

Preparation process of blends:

To produce Bio diesel/fatty acid methyl esters (FAME) the regular methodical reaction called transesterification is implied always which signifies oil to be mixed with methanol and base-catalyst using a methanolysis reaction. First, mixture of potassium hydroxide is prepared where in measured amount of Methanol is added with appropriate proportions of KOH. A stirring action action is provided such that all the pallets of potassium hydroxide get dissolved in Methanol. Later the solution of Potassium Meth-oxide is blended with 900ml of Palm oil in a round bottom flask and heated indirectly using Magnetic stirrer with hot plate at a temperature of 70OC and constant rpm for 1.5hrs. The transesterification reaction involving production of bio diesel is endothermic reaction where in the catalyst used to reduce the temperature of reaction is any base hydroxide. After the stipulated time the mixture is cooled and poured in separating funnel and allowed for gravity separation process. Later the glycerol content is removed and demineralised water (in Proper Proportion) is poured with the crude biodiesel in separating funnel and allowed for phase separation process which still comprises of Glycerol embedded. The addition of demineralised water separates the glycerol and filters the biodiesel. The process of washing is

continued till no glycerol is found and the Methyl ester is pure in form and blended in proportions like PB10; PB20 and PB30. Later blends like PB10E5D85 (Biodiesel 10%vol; Ethanol 5%vol; and Diesel 85%vol), PB10E10D80(Biodiesel 10%vol; Ethanol 10%vol; and Diesel 80%vol); PB20E5D75(Biodiesel 20%vol; Ethanol 5%vol; and Diesel 75%vol); PB20E10D70(Biodiesel 20%vol; Ethanol 10%vol; and Diesel 70%vol); PB30E5D65 (Biodiesel 30%vol; Ethanol 5%vol; and Diesel 65%vol)and PB30E10D60 (Biodiesel 30%vol; Ethanol 10%vol; and Diesel 60%vol) were prepared.

Thermo Physical Property Tables of Fuel Blends

	Unit	Ethanol	PB100	Diesel	PB10
Density	g/cm3	0.76	0.9	0.83	0.837
Viscosity at 40oC	mm2/sec	1.32	4.51	3.6	3.691
Flash Point	^{o}C	20	135	62	69.3
Auto Ignition Temperature	^{o}C	412	288	210	217
Pour Point	^{o}C	<-30	3	1	1.2
Cetane Number		10	56	4.5	9.65
Acid Value	mgKOH /gm		0.22	0.06	0.07
Net heating Value	MJ/kg	26.9	39.6	42.5	42.2

	PB10E5	PB10E10	PB20	PB20E5	PB20E10
Density	0.833	0.829	0.844	0.84	0.827
Viscosity at 40oC	3.57	3.45	3.7	3.65	3.289
Flash Point	66.8	64.37	76	73.7	65.28
Auto Ignition Temperature	227	237.2	225	234	262.8
Pour Point			1.4		
Cetane Number	9.66	9.685	14	14.5	13.84
Acid Value	0.072	0.068	.09	0.087	0.073
Net heating Value	41.4	40.7	41	41.2	38.9

	PB30	PB30E5	PB30E10
Density	0.851	0.846	0.842
Viscosity at 40oC	3.873	3.74535	3.6177
Flash Point	83.9	80.705	77.51
Auto Ignition Temperature	233.4	242.33	251.26
Pour Point	1.6		
Cetane Number	19.9	19.45	18.955
Acid Value	0.1	0.1026	0.0972
Net heating Value	41.6	40.9	40.2

2. Experimental Procedure

The Performance and emission test were conducted on single cylinder 4-stroke Direct Injection compression ignition Engine with Eddy current type dynamometer for various fuel blends. The engine specifications are mentioned

Fig1: Trans-esterified Mixture

Fig2: Crude Methyl ester before Washing

Fig3: Palm Oil Metyl ester

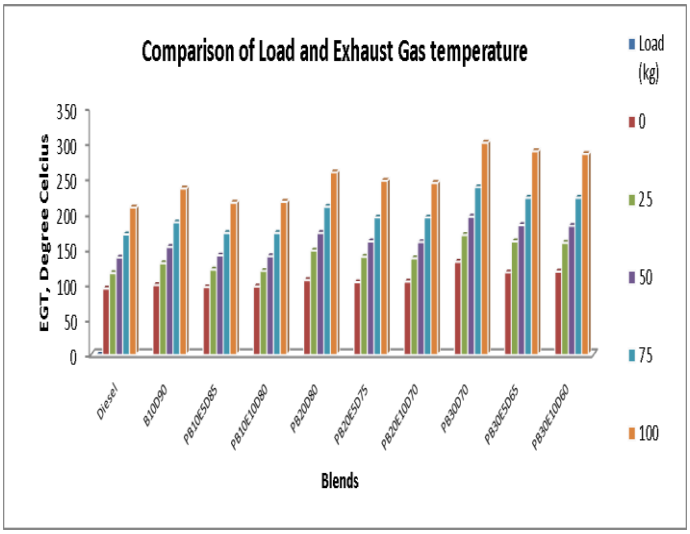
Fig4: Palm Methyl Ester left for Sepearion after washing

The constant engine operating parameters are Engine speed 1500rpm compression ratio 17.5, injection pressure of 205 bars and injection timing of 23^{0}bTDC. In current day the engine parameters mentioned above are kept constant and the only variation is load acting on the engine. Based on the above concept, the measurable output parameters are Thermal Performance parameters and Engine emissions for various loads and Blend of Bio diesel-ethanol-Diesel. The gas analyser used was 4-way in nature that can measure NOx, HC, CO and CO2.

3. Results and Discussion

Variation of Exhaust Gas Temperature with respect to load

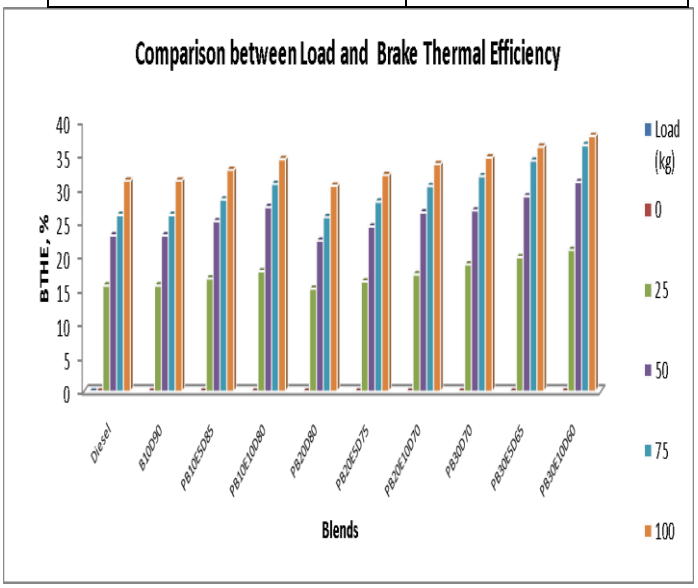
The pictorial representation signifies the study of variation of exhaust gas temperature coming from the engine and load variation. At constant rpm of 1500, as the load increases the fuel intake also increases signifying to heat supplied also increases proportionately thereby increasing the temperature carried away by the exhaust gases. Also if the blend percentile of Biodiesel increases the Exhaust gas temperature also increases. PB30D70 exhibits the maximum Exhaust gas temperatures. The addition of ethanol depreciates the exhaust gas temperature on a average of 7.6%.



Variation of Brake Thermal Efficiency with respect to load

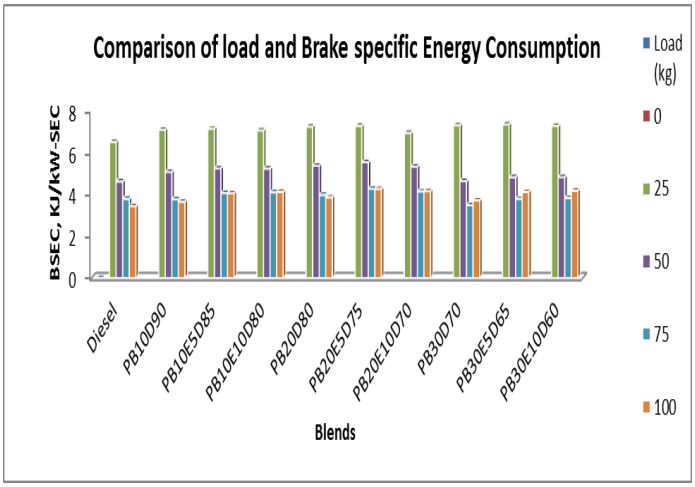
The brake thermal efficiency is directly proportional to Brake Power/Load obtained and inversely to heat supplied. As the load increases the brake thermal efficiency also increases for all blends. The effect of ethanol addition increases the brake thermal efficiency with average of 7.5% for adulteration of 5% ethanol and 9% for 10% ethanol addition in Palm Biodiesel-Diesel Blends (Condition: maximum load). The reason for increase in brake thermal efficiency might be quick ignition of ethanol in comparison of Blends of biodiesel. The effect of ethanol acts as a catalyst igniting earlier than Palm Biodiesel and providing higher air temperature for the blends to undergo combustion.

Make and Model	Kirloskar Oil Engine TV1
Type	4-stroke single cylinder, water Cooled
Bore and stroke	80mm and 110mm
Compression ratio	17.5:1
Maximum Speed	1500rpm
Exhaust Gas Analyzer Make	Numen
Measureable Gases	CO, CO2, NOx and HC



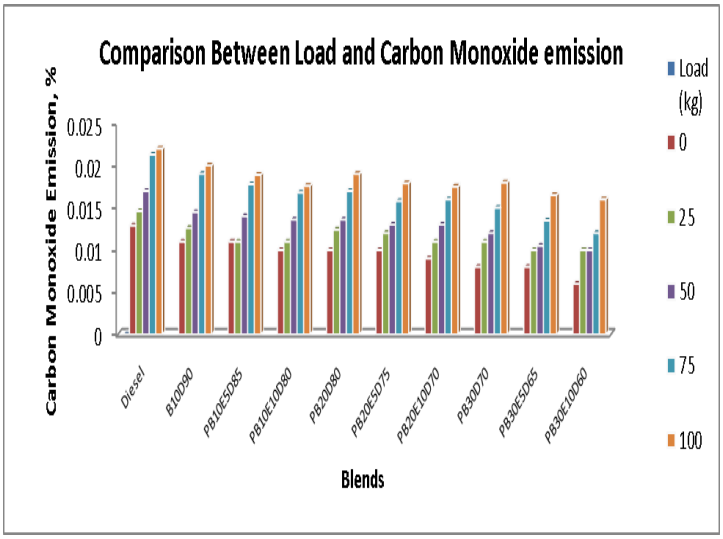
Variation of Brake Specific Energy Consumption with respect to load

Brake Specific Energy Consumption (B.S.E.C.) is the energy used by the engine to produce unit power. For fuels having lesser calorific value, the term of Brake Specific Fuel Consumption is Higher when compared to Mineral Diesel, so the fact for comparison is Brake Specific Energy consumption. It is observed that as the load increases the BSEC value also decrease. Also at 9kg load the BSEC values equalizes the BSEC values at 12kg load.



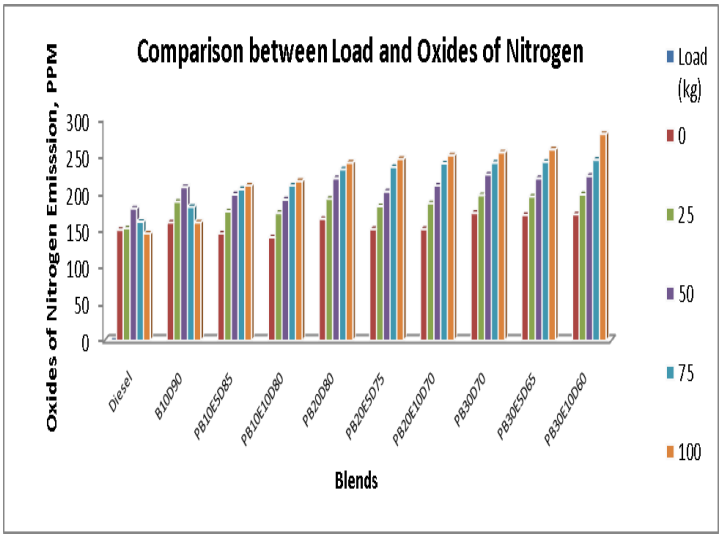
Variation of Carbon Monoxide emission with respect to load

Carbon monoxide emissions coming from engine exhaust signify incomplete combustion inside the combustion chamber. The reason for incomplete combustion can either amount of Air/oxygen available for combustion or time lack for combustion. During experimental analysis, diesel fuel exhibited the maximum readings of CO emissions. The doping of Ethanol in the blends of palm oil Methyl ester and diesel reduced the CO emissions by about 10.5% on an average for all blends. Alcohol/ethanol addition promoted the combustion by raising the air temperature to reach auto ignition temperature and also providing indirect preheating to biodiesel to undergo combustion. Biodiesel/ Palm oil Methyl ester also bears high oxygen content than that of fossil diesel.



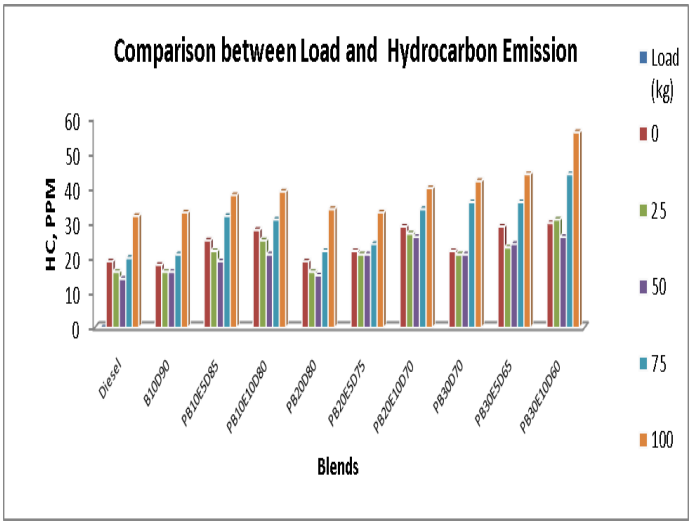
Variation of Oxides of Nitrogen emission with respect to load.

Formation of Oxides of Nitrogen is a factor of temperature present in the combustion chamber of engine. Higher Exhaust Gas Temperatures greater is the formation of nitrous oxides. NOx emission plays a very important role in the formation of photo chemical smog and hazardous to living beings, causing respiratory problems. During investigation, the NOx emissions (in ppm) increased gradually as the load increased. The addition of ethanol promotes the combustion for the blended diesel-biodiesel fuels, hence increasing the oxides of nitrogen approximately by 9.2%. It is observed, that NOx emission is highest for Blends of Bio Diesel-Diesel. However NOx emissions also indirectly signify the engine heat supplied by fuel is higher bringing the engine temperature to elevated regions. Also NOx emissions are higher during long run of engine.



Variation of Hydrocarbon emission with Respect to Load.

The hydrocarbon emissions are significance of basic phenomenon of incomplete combustion. It was observed that during the addition of ethanol increases the hydrocarbon emissions. Alcohols in spite of readily usable nature in SI Engines are found its dominancy due to aldehyde emissions and hydrocarbon emission. The addition of ethanol does promote the combustion characteristics by increasing the cetane number of fuels, but also increases slightly Hydrocarbon emission. The addition of Ethanol gives a almost same results of hydrocarbon emission of that of other blends of ethanol-Palm Oil Methyl ester



4. INFERENCES

Ethanol addition in blends provided a better thermal efficiency than regular blend of biodiesel-diesel, inculcating an increase of approximately 8.3%. The brake specific fuel consumption recorded was higher as the heat supplied for specific power was low, under various load conditions. The carbon monoxide emissions reduced on addition of ethanol in the blends of palm oil methyl ester-diesel. The use of bio-fuels increases the combustion process and proof of this is higher carbon Dioxide emissions signifying cleaner emission. The Hydrocarbon emissions recorded an on same loci of all blends used inside the engine. The increase in cylinder/combustion chamber temperature there by increasing the tendency of inert nitrogen to form oxides of nitrogen. Major Advantage of using bio fuels is that they have the lesser calorific value and high viscosity which restricts the blending percentage and hence if higher blending percentage required, preheating is must.

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