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Improved Method of CI Engine Performance Using Pongamia Oil for Various Blends of Biofuel

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Abstract: **As the luxury factor in transportation increases day by day, the number of vehicles on road increases and so is their emission. Ever depleting petroleum resources push researchers towards the search of new fuels and improved methods of combustion. Biodiesel obtained from vegetable oils and animal fats has comparatively low profile pollutant emissions and can be easily substituted for mineral diesel. Viscosity and density of fuel greatly influences the atomization and vaporization patterns of fuel sprays. At higher temperatures, the viscosity of fuel decreases which enhances the atomization. Better atomization improves the combustion quality of the fuel and hence reduces the HC and CO emission. In this work three blends of pungamia oil with diesel is heated to 60, 70 and 80o C. The preheated fuel is used in direct injection C I engine and the performance curves were obtained. Emission analysis was also done and the emission curves were also presented. The results show that B 20 blend gives good combustion and emission characteristics when heated to 70o C before inlet. The analysis of graph shows that B20 gives better thermal efficiency and low emission characteristics compared to diesel. The NOx emissions were drastically reduced.**

***Index terms*— Diesel - Pungamia blends, Hydro-Carbons, NOx, Pre-heating, Spray Test**

I. INTRODUCTION

A large amount of fuel is consumed in transportation sectors where diesel vehicles are much preferred for long distance transports. The diesel fuel plays a very important role in development of transportation sector and also the country's economy. Due to intense exploration, the amount of oil remaining in the ground is highly uncertain and some of the oil remaining can be accessed only by using complex technologies. In the wake of situation there is urgent need to promote use of alternative fuels which must be technically feasible, economically and environmentally acceptable and readily available [1]. Emission is also one of the major problem in diesel engines as it emits more pollutants than the petrol engines. So, researchers have succeeded in getting bio fuels prepared from seeds of different plants as a good substitute for mineral diesel. The feedstock for biodiesel can be varied from one country to another depending on their agricultural practices and geographical locations. The selection of the best feedstock is necessary to keep the production cost of the biofuel low. Non-edible oils such as neem, pongamia, jatropha as well as animal fats and waste cooking oil had been widely used. The problem associated is the high content of free fatty acids. Pretreatment has to be carried out in order to remove these free fatty acids [3].

The biodiesel industry is still behind the conventional oil and gas industry in terms of financial profitability and infrastructure support. Mechanisms to encourage a wider participation of the global community towards the reduction of greenhouse gas emissions will further promote the use of renewable fuels. The present investigation focuses on the improved method of using pongamia oil as a biofuel blended with diesel [5].

Vegetable oils have become more attractive recently because of their environmental benefits and the fact that they are made from renewable resources. More than 100 years ago, Rudolph Diesel successfully tested vegetable oils as fuel for his engine.

As with 100% biodiesel to ensure the fuel injectors atomize the vegetable oil in the correct pattern for efficient combustion, vegetable oil fuel must be heated to reduce its viscosity to that of diesel, either by electric coils or heat exchangers. This is easier in warm or temperate climates. Vegetable oil can also be used in many older diesel engines that do not use common rail or unit injection electronic diesel injection systems.

Experimental investigations are carried out on a single cylinder diesel engine to examine the suitability of pongamia oil blends as an alternate fuel [4]. The performance, combustion and emission characteristics of blends are evaluated and compared with diesel [7]. No difficulty was faced at the time of starting the engine and the engine ran smoothly over the range of engine speed [2].

The spray test for three blends at three different temperatures were conducted. B20 has a wider spray angle at 800C. Wider the spray angle more atomization of the fuel takes place and due to the wider spray angle homogenous mixture is formed which results in good combustion [8].

Usage of pongamia biofuel blend has shown improvement in the emission characteristics [6]. The specific fuel consumption (SFC) decreases for B10 and B20 than diesel at 800C. The brake thermal efficiency is also increased for these two blends than diesel and the NOx emission is reduced to half when compared to diesel [9].

2. BIO DEISDEL TESTING PROPERTIES:

2.1 Pongamia Oil:

Biofuel, which is used as an alternative diesel fuel, is made up of renewable source such as vegetable oil and animal fats. This oil is derived from the seeds of the plant millettia pinnata [10]

The objective of the present investigation is to use this oil as a blend for diesel. The fuel properties such as viscosity, density, calorific value, were determined and are compared with standard diesel fuel. This plant is common throughout Asia.

Figure: 2.1 Seeds of pongamia tree

2.2 Cultivation:

The plant starts yielding pods from the fifth year with the yields increasing each year until it stabilizes around the tenth year. Seeds are usually harvested in the spring, each seed weighing from about 1.1 grams to 1.8 grams.

Pongamia oil is extracted from the seeds by cold pressing, solvent extraction or by expeller pressing. The color of the oil is brown color. It has a high content of triglycerides. In the cold pressing process, hydraulic press is used to extract the oil from the seed.

2.3 Traditional Uses:

Pongamia oil is mainly used in soap making industries, leather tanning industries and also it is used as a lamp oil and also as a lubricating oil. It is not used as a cooking oil because of its odour and its bitter taste. It is used as a traditional medicine for skin disease and liver disease. It is used as an insecticide and as also fish poison due to the karanjin and pongamol chemicals present in it.

Component	Percentage
Oil	27-39
Protein	17-37
Starch	6-7
Crude fiber	5-7
Moisture	15-20

Table 2.1: Nutritional contents in pongamia seed

2.4 Physical Properties:

S. No	Parameter	Diesel	Pongamia Oil
1	Density	830 Kg/m^3	924 Kg/m^3
2	Viscosity	2.54 mm^2/s	40.2 mm^2/s
3	Specific gravity	0.83	0.925
4	Calorific value	44300 KJ/Kg	36576.53 KJ/Kg

Table 2.2: Physical properties of Pongamia Oil

2.4.1 Kinematic Viscosity:

Viscosity is a measure of a fluid's resistance to flow. The greater the viscosity, the less readily the liquid flows. It is one of the most important parameters required in the design of combustion processes. Kinematic viscosity was measured with a Redwood viscometer at 60o C and 70o C for B10, B20 and B30.

Kinematic viscosity was calculated by Redwood viscometer using equation:

Kinematic viscosity = A * t – (B/t)

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Where:

A = constant value =0.26

B = constant value =172

T = time in seconds.

2.4.2 Density:

Density is defined as the ratio between mass and volume or mass per unit volume. Density of oil is another fuel property that directly affects engine performance. Density for pongamia oil is about 924 Kg/m3. The density for various blends with their viscosity is calculated.

Fuel	**Density (g/cc)**	**Viscosity (cSt)**
B 10 (60°C)	0.896	12.73
B 10 (70°C)	0.894	9.37
B 20 (60°C)	0.898	13.95
B 20 (70°C)	0.896	9.56
B 30 (60°C)	0.90	15.15
B 30 (70°C)	0.896	10.48

Table: 2.3 Density and Viscosity of B10, B20, B30

2.4.3 Specific Gravity:

Specific gravity is the ratio of the density of a substance to the density of a reference substance; equivalently, it is the ratio of the mass of a substance to the mass of a reference substance for the same given volume. The specific gravity of pongamia oil is 0.925.

2.4.4 Calorific Value:

The calorific value or heat of combustion or heating value of a sample of fuel is defined as the amount of heat evolved when a unit weight of the fuel is completely burnt and the products of combustion cooled to a standard temperature of 298 K. The calorific value for pongamia oil is 36576.53 KJ/Kg.

2.5 Chemical Properties of Pongamia Oil:

Properties	Pongamia Oil
Cetane number	42
Iodine value	86.5-87
Saponification value	184-187
Acid value	4.0-12

Table 2.4: chemical properties of pongamia oil

2.5.1 Saponification Value:

Saponification is an organic chemical reaction that utilizes an alkali to cleave an ester into a carboxylic acid and alcohol. As we will see shortly, the primary use for this reaction is during the production of soap products. The terms ester, carboxylic acid and alcohol are functional groups. A functional group is simply a group of molecules or atoms that we can easily identify in a compound. The saponification value of pongamia oil is at range of 184-187.

2.5.2 Iodine Value:

The iodine number gives an indication about the amount of unsaturated fatty compounds in the oil and thereby indicates the ease of oxidation or drying capacity of the oil. However, it does not give any information on the nature of the unsaturated and saturated compounds. As the number of double bonds does not change during trans-esterification, measuring the iodine value in feedstock oil will give an indication of the stability of the biodiesel produced from the same feedstock. The iodine value of this oil is 86.5-87(mg KOH/gm oil).

2.6 Flash Point and Fire Point:

The flash point is the lowest temperature at which the vapour of a volatile material will ignite, when given an ignition source. The fire point is the lowest temperature at which the vapor will keep burning after being ignited and the ignition source removed. The fire point is higher than the flash point, because at the flash point the vapor may be expected to cease burning when the ignition source is removed.

Flash Point (°C)	**Fire Point (°C)**
Diesel: 51	Diesel: 57
B10: 70	B10: 74
B20: 76	B20: 78
B30: 82	B30: 85

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Table 2.5: Flash Point and Fire Point of B10, B20, B30 and Diesel

3. EXPERIMENTAL SETUP:

The experiment is carried out at constant speed of 1500. The various blends are pre- heated before injected into the combustion chamber. At 70oC and 80oC the viscosity of the blends reduces drastically. So, with the help of induction heater the blends are heated to the required temperature and with the help of the stirrer the fuel is heated uniformly in all directions. After the required temperature is reached the diesel injection is cut off and the blended fuel is made to flow into the combustion chamber. Exhaust gas analyzers were used to analyze the emission levels with the help of probe in the exhaust air outlet to atmosphere. With the help of exhaust gas analyzer, the emission values were determined. Hydrocarbon, Carbon di oxide, Carbon monoxide and NOx values are determined.

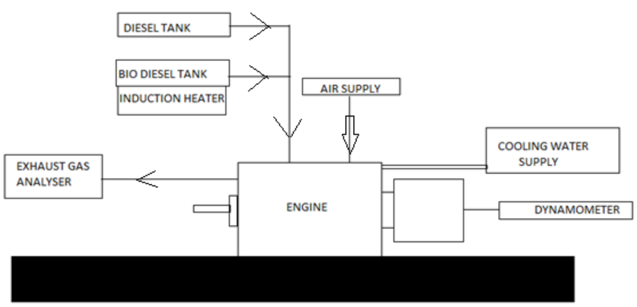

Figure 3.1: Schematic diagram of Bio-Diesel engine

3.1 ENGINE SPECIFICATIONS:

Engine Parameters	Specifications
Engine	Four stroke single cylinder
Rated power	5 H. P
Speed	1500 (constant) rpm
Bore	87.5mm
Stroke	110mm
Volume	661cc
Nozzle type	Single hole
Injector pressure	200 bar
Drum diameter	34.85 cm
Rope diameter	1.43 cm

Table: 3.1 C. I engine specifications

3.2 SPRAY TEST:

Spray test is conducted for three blends at the required temperature and with the single point injector, constantly at 200 bar pressure and the spray patterns were recorded.

Figure 3.2: Spray test for B10, B20, B30 blends

From the spray patterns the blend B20 at 80oC gives wider sprays with better atomization, which increases the amount of fuel burning with reduced emission complexity.

3.3 EXHAUST GAS ANALYZER:

Gas analyzers may be hand operated or automatic. The most common analyzers of the former type are based on the absorption principle: the components of a gas mixture are absorbed one after another by different reagents. Automatic gas analyzers continuously measure some physical or physicochemical property of a gas mixture as a whole or of its separate components. The emissions test is done with Exhaust Gas Analyzer.

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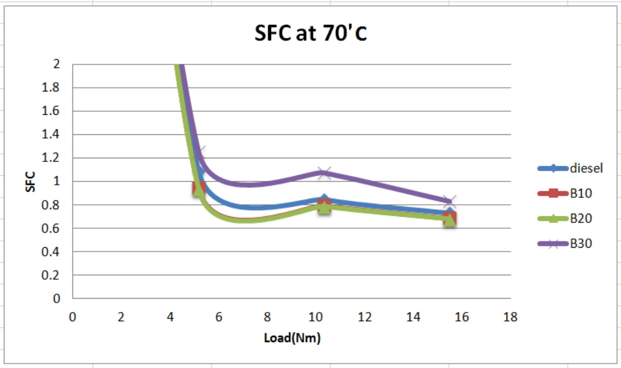
Figure: 3.3 Exhaust Gas Analyzer

4. RESULTS AND DISCUSSIONS:

4.1 SPECIFIC FUEL CONSUMPTION:

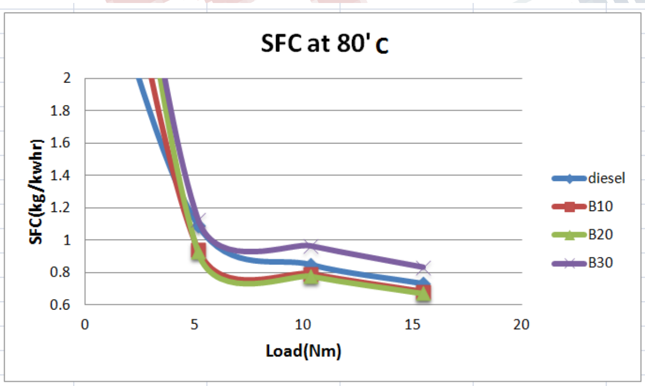
4.1.1 Load vs Specific Fuel Consumption (SFC) at 700C:



Graph: 4.1

Specific fuel oil consumption is the amount of fuel consumed in unit time for generating per KW of power in an engine. Specific Fuel Consumption (SFC) is almost equal for diesel, B10 and B20. B30 has the highest SFC. As the load increases the SFC values decreases.

4.1.2 Load vs Specific Fuel Consumption (SFC) at 800C:

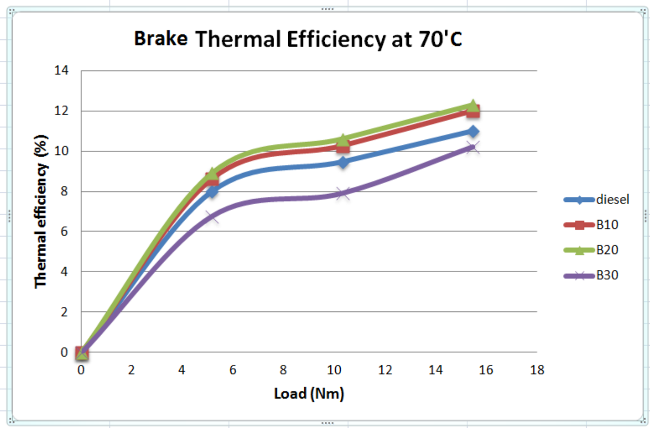


Graph: 4.2

All fuel blends show similar variation for SFC with increase in load. The Specific fuel consumption is least for B20 blend which is about 0.77 kg/kwhr at 10 Nm load. The specific fuel consumption is least for both B10 and B20 blends and it is maximum for B30 blend.

4.2 BRAKE THERMANL EFFICIENCY:

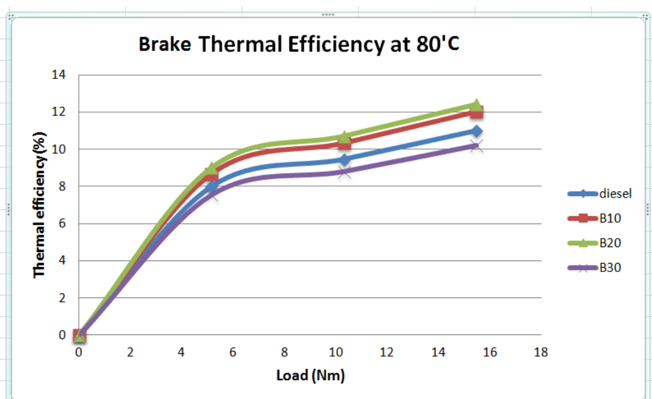
4.2.1 Load vs Brake Thermal Efficiency at 700C:



Graph: 4.3

From the graph, it has been observed that the thermal Efficiency for B20 & B10 is higher than the diesel and B30 and the contrasting part is that the thermal Efficiency of B30 is less than that of diesel. As the load increases the Efficiency also increases. Efficiency of B20 is greater than diesel at 9 Kgf.

4.2.2 Load vs Brake Thermal Efficiency at 800C:

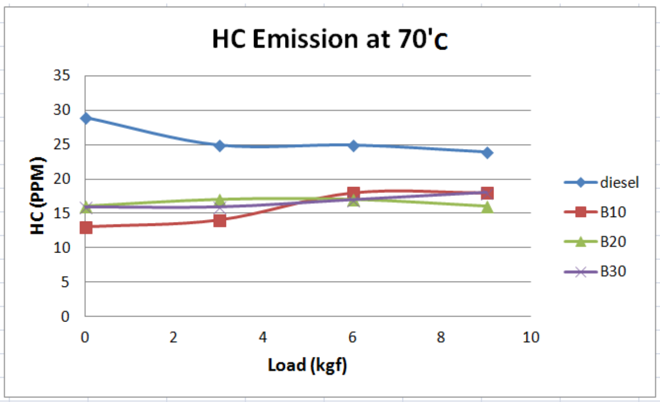


Graph 4.4

From the graph, it has been observed that thermal Efficiency at 800C for B30 has been reduced when compared to same blend at 700C.

4.3HC EMISSIONS:

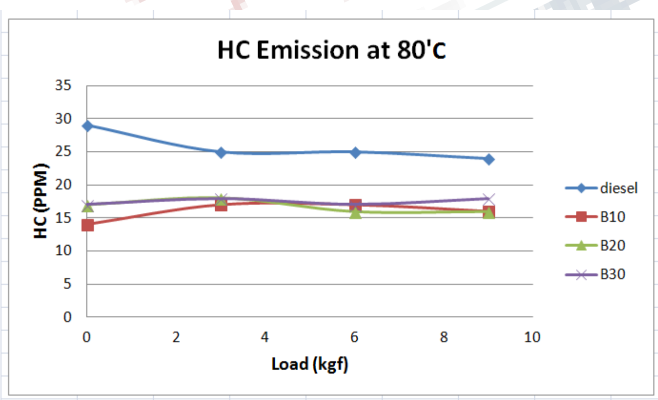
4.3.1 Load vs HC emission at 700 C:



Graph: 4.5

Hydrocarbon emission is calculated with the help of emission analyzer for various loads in the range from 0 to 9 Kgf for the three blends and the hydrocarbon values are reducing at a promising rate for B20 blend. There is a vast difference between the emission rates of diesel and the blends. Hydrocarbon is measured in parts per million with respect to various loads for three blends. The reduction in HC emission may be due to the presence of inherent oxygen which will promote better combustion.

4.3.2 Load vs HC emission at 800 C:

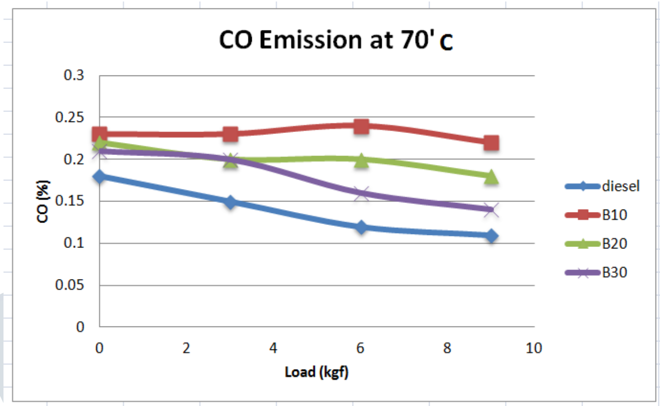


Graph: 4.6

Hydrocarbon emission reduces from 24 ppm for diesel to 16 ppm for B20 blend. B30 blend has slightly higher than other two blends. The increase in load results in no significant change in HC emission.

4.5 CO EMISSIONS:

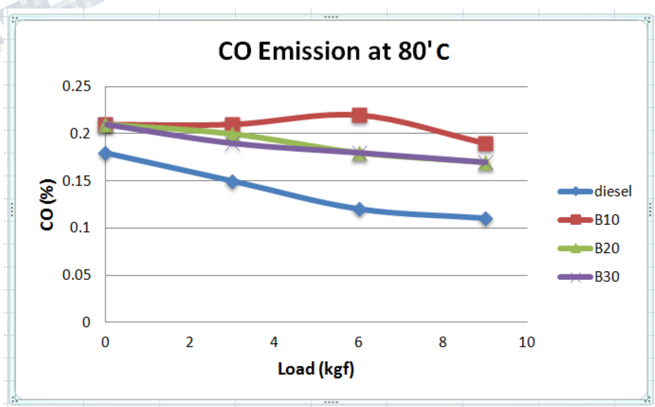
4.5.1 Load vs CO emission at 700C:



Graph: 4.7

From the graph, it has been observed that CO emission has been increased for all the blends when compared to diesel. Among the blends B10 has the highest emission.

4.5.2 Load vs CO emission at 800C:



Graph: 4.8

From the graph, it has been observed that CO emission has been reduced for all blends much less than 700C. CO emissions are found to be least for diesel and the emissions are moderate for both B30 and B20 blends. The emissions are found to be high for B10 blend with increase in load.

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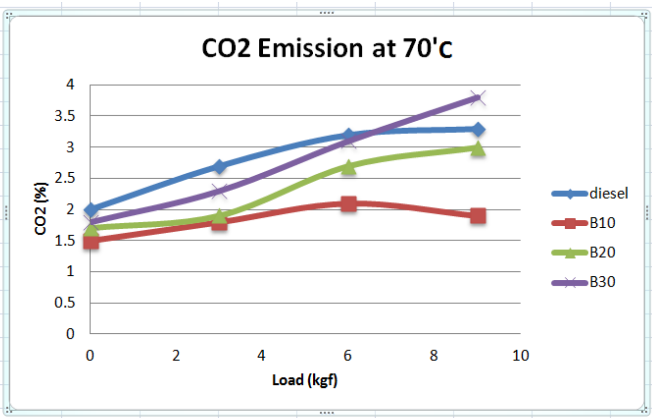
4.6 CO2 EMISSIONS:

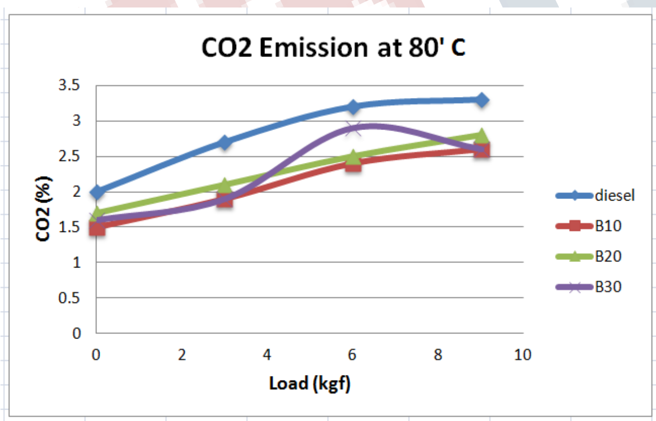
4.6.1 Load vs CO2 emission at 700C:



Graph: 4.9

CO2 emission decreases for B20 and B10, but there is a slight increase in B30 at higher loads. B10 has the lowest emission of all blends while B30 has the highest value for CO2 emission.

4.6.2 Load vs CO2 emission at 800C:

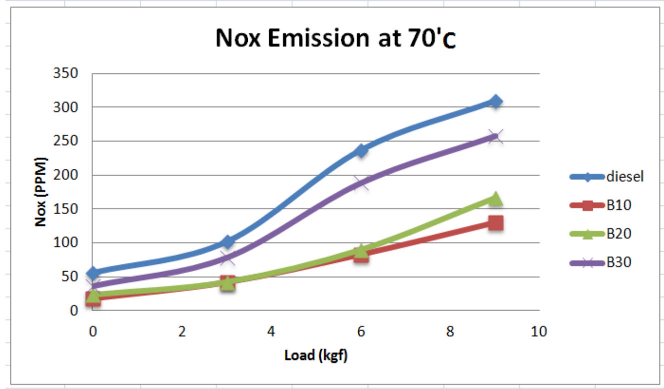


Graph: 4.10

CO2 emission for all the blends has been reduced drastically when compared to diesel at 800C is lesser than 700C. At 6 Kgf, B30 has higher emission when compared to the same load at 700C.

4.7 NOX EMISSIONS:

4.7.1 Load vs NOx emission at 700C:

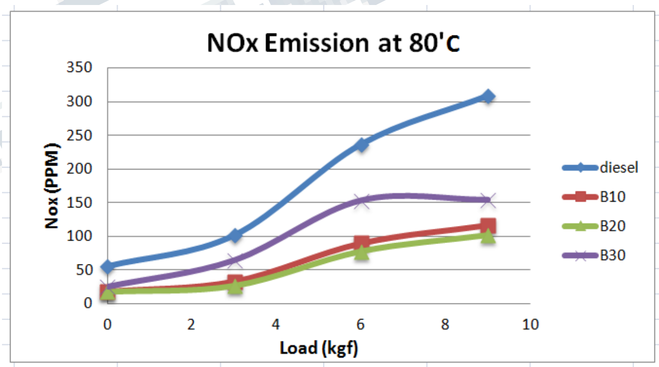


Graph: 4.11

From the graph, it has been clearly shown that the NOx emission for blends are less than the diesel among the blends B20 and B10 have the least emission till 6Kg of load after which B20 increases

Slightly and NOx reduces by 50% in B20.

4.7.2 Load vs NOx emission at 800C:



Graph: 4.12

At 800C, the B20 blend has a lower rate of emission than B10 when compared to 700C. It was only about 100 ppm of NOx at 9Kgf load for B20 blend and the emissions are very high for diesel with increasing load. B10 and B30 have moderate emissions in between diesel and B20 blend.

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CONCLUSIONS:

In the present investigation pongamia oil is blended with diesel in three proportions in varying temperatures. The performance and emission characteristics has evaluated. The performance characteristics of blended biofuel has shown a little increase in the efficiency compared to diesel. Graph shows B20 and B10 blends are increased by 2% than diesel, but B30 blend decreases in efficiency than diesel and the other two blends. Total fuel consumption (TFC) of B30 is greater than diesel and other blends. TFC for B10 and B20 are same and slightly decreasing than diesel. TFC for diesel at 800C is lesser than 700C.Overall performance shows improvement for B20 biofuel blend than diesel in thermal efficiency.

The emission characteristics of pongamia blend with diesel in three proportions at 700C and 800C has evaluated using exhaust gas analyzer. Hydrocarbon (HC) emission level is decreased in case of all three blends when compared to diesel. Out of the three blends B20 has lowest hydrocarbon emission. NOx emission level is decreased by 50% in the blends in comparison with diesel. At 800C B20 has the lowest NOx emission when compared to all other fuels. Carbon di oxide emission level has decreased in B20 and B10 and CO_2 level is increased in B30 than diesel at 700C but at 800C all the three blends has lesser CO_2 emission level. CO emission increases in all the three blends when compared to diesel but at low rate (0.05%). Only CO level increases in the blends than diesel. Overall in emission levels NOX reduces at a high rate in blended biofuel than other emission characteristics. This idea can be practically implemented in automobile by using EGR. With the heat from the exhaust valve the blended biofuel can be heated to the required temperature than using other external source for heating.

REFERENCE:

[1]. Taha, Ahmed & Abdel-salam, Tarek & Vellakal, Madhu. (2013). "ALTERNATIVE FUELS FOR INTERNAL COMBUSTION ENGINES: AN OVERVIEW OF THE CURRENT RESEARCH". 279-306. 10.13140/2.1.3008.5920.

[2]. Mr. Hitesh J. Yadav, Dr. Pravin P. Rathod and Prof. Sorathiya Arvind S.(2012)"Biodiesel preparation from Karanja Oil – an Overview" INTERNATIONAL JOURNAL OF ADVANCED ENGINEERING RESEARCH AND STUDIES.Vol. I.Issue III.42-46

[3]. Kumar Gupta, Arun & Rahul Kiro, Mani & Deo, Goutam. (2016). "Biodiesel production from a free fatty acid containing Karanja oil by a single-step heterogeneously catalyzed process." International Journal of Green Energy. 13. 489-496. 10.1080/15435075.2014.977440.

[4]. Halder, P., Paul, N., & Beg, M. (2014). "Prospect of Pongamia pinnata(Karanja) in Bangladesh: A Sustainable Source of Liquid Fuel". Journal Of Renewable Energy, 2014, 1-12. http://dx.doi.org/10.1155/2014/647324

[5]. G. Dwivedi, S. Jain and M. Sharma, "Pongamia as a Source of Biodiesel in India", Smart Grid and Renewable Energy, Vol. 2 No. 3, 2011, pp. 184-189. doi: 10.4236/sgre.2011.23022.

[6]. Panigrahi N, Mohanty MK, Pradhan AK (2012) "Non-edible karanja biodiesel- A sustainable fuel for CI engine". International Journal of Engineering Research and Applications 2(6): 853–860.

[7]. Abdulkadir Yasar, Mustafa Ozcanli1, Hasan Serin and Kadir Aydin (2014) "Compression Ratio and Injection Angle Effect on Performance and Emissions of a Diesel Engine Fueled with Rapeseed Biodiesel and Diesel Fuel" 3rd International Conference on Geological and Environmental Sciences IPCBEE vol. 73 IACSIT Press, Singapore DOI: 10.7763/IPCBEE. 2014. V73. 5

[8]. Dhananjay Kumar Srivatsava, Avinash Kumar Agarwal (2008). "Particulate matter emissions from single cylinder diesel engine: effect on engine load on size and number distribution"

[9]. Ganesan V. (2003), "Internal combustion Engines", Mcgraw Hill Publications, New Delhi.

[10]. Vivek and A.K. Gupta (2004). "Biodiesel production from karanja oil" Journal of Scientific& Industrial Research 63.