Analysis of Performance, Combustion & Emission for Single Cylinder Diesel Engine using Blends of KOME

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ABSTRACT

Due to increase in the consumption of Petroleum products and the value climb of petroleum fuel day to day is really creating problems for developing countries who are dependent on oversea suppliers and pay large amount of import bill, It bring down our Economy. Other than the economy and development, use of fossil fuel also leads to a major problem like global warming and climate change. The emission of unsafe gasses like CO, NOx, CO2, and HC (Hydrocarbons) causes acid rain, health hazard and also global warming. In the last few years interest & activity has grown up around the globe to find a substitute of fossil fuel. The objectives of this study are the production process, fuel properties, oil content, engines testing and engine analysis of biodiesel from Karanja oil which is known as (KOME). The Parameters like Combustion, Performance and Emission characteristics of blends are evaluated and compared with Diesel fuel. There was not any difficulty faced at the time of starting the engine and the engine ran easily over the range different Load condition at Constant Speed. All the parameters were under the range of the acceptable conditions. The range of B10 to B20 is considered to be the better fuel. Hence Biodiesel from Karanja Oil is quite suitable as an alternative fuel to the diesel fuel.

***Key Words*: Karanja oil methyl ester (KOME), Karanja, performance, Bio-Diesel Blends, CO, NOx, HC & CO2, Blends, performance, Bio-Diesel Blends, CO, NOx, HC & CO2, Blends.**

I INTRODUCTION

In the early 19the century the Dr. Rudolf diesel has invented the biodiesel from the peanut oil and it was experimented for the compression Ignition Engine. But then, due easily accessibility of the crude oil, the demand is reduced for using biodiesel in the CI engine It is very regular these days to discover that each nation is in the race to discover reasonable and moderate option fuel alternatives for diesel motor as the present-day diesel fuel hold is draining quick. What's more, the cost of customary diesel fuel is soaring because of incredible requirement, exponential increment of vehicles number on street and political turmoil. Hence, it is a dire requirement for India too to scan for an alternative to run diesel engine utilizing a fuel other than ordinary and petroleum based diesel. Biodiesel, as diesel engine fuel elective, gets more consideration among numerous possible alternatives. Karanja is a dry season tolerant tree, adaptable for different Seasons, semi-deciduous tree. A medium measured bald tree with a short stem and spreading crown around 5-20 meter stature with a major shade which appropriated consistently wide. Aside from these focal points are Karanja oil can be utilized as the as option fuel for immaculate diesel. In the nation like India, residential usage of the petroleum items around 16 rate of the aggregate imports. Furthermore, add up to import is around 3.4 thousand crores Indian Rupees (half billion dollar) is spent for the mineral diesel items in the year 2012. This corrupts our Economic conditions because of utilization of more measure of diesel fuel. As there is increment in the interest for the Petroleum items and corruption of fossil powers, there prerequisite of the option fuel for the diesel fuel or the diesel fuel can be mixed with the known extent of alternate oils of fuel. Furthermore, with expanding the request of the petroleum items uniquely in the diesel energized substantial motors, there is increment in the discharge of toxicant emission(HC , NOx and Carbon monoxide) to the climate and causes serious medical problems to the human life and the other living creatures. In the creating nation like India, non-eatable oil like Karanja oil can be utilized as the crude item for the making of the biodiesel which are comparative properties of the immaculate diesel. This procedure is development of basic ester items from the tri-glyceride non-palatable oil.

II DETERMINING THE PROPERTIES OF THE BLENDS

In the Preparation of Biodiesel, Blends of biodiesel and customary hydrocarbon-based diesel are delivered by blending biodiesel and diesel in reasonable extents under fitting conditions. Ordinarily, it is known as the "B" component to characterize the rate of biodiesel in any fuel blend.

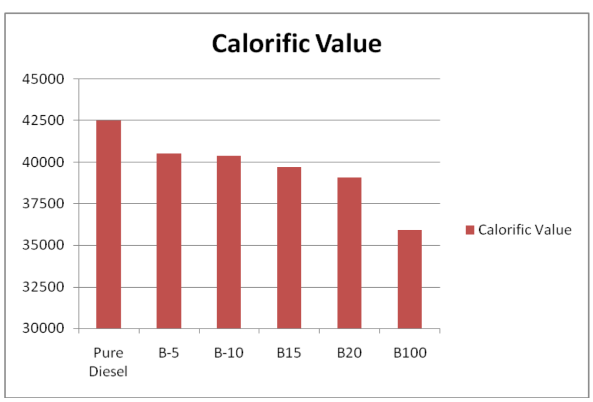

Fig -1: Change in the Calorific Value of the different Blends

From Above figure 1, it has been seen that the Calorific Value diminished by increment in the proportion of the KOME mixes, the reason is because of the nearness of the Un-saturated (Alkenes and Alkynes structure) Hydro-Carbon and Oxygen Residue (Carbonyl bonds) will increment by expanding the Blend rate. Because the temperature require to break these bonds are higher.

The Dynamic Viscosity and Kinematic Viscosities were calibrated at the 40°. The Viscosity of the Pure Diesel is less when contrasted with the Biodiesel. The thickness will increments by increment in the Percentage of the Blend as appeared in the underneath Figure.

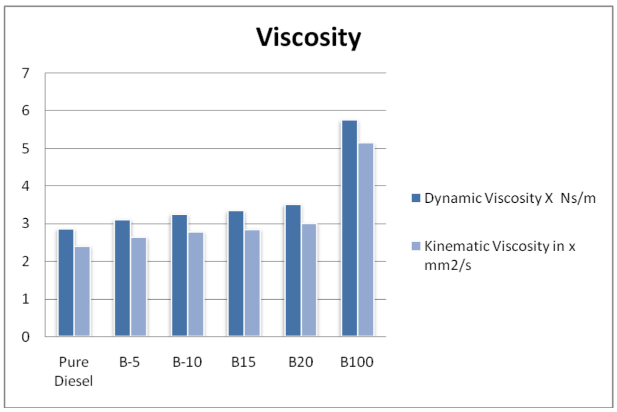

Fig -2: Change in the Viscosities of the different Blends

The Flash Point is characterized as the base temperature at which the Fuel begins touching off era of the start happens; The Fire point is minimal temperature at which the Vaporization of the fuel proceeds subsequent to smoldering the fuel. The Flash Point and Fire Point is resolved for the Diesel and the Different Biodiesel Blends, it is discovered that as the Percentage of the Biodiesel expands the Burning of the Fuel happens at higher temperature i.e., The Flash and Fire indicate is going increment as appeared in the underneath Figure No.3, this is because of the thick way of the fuel and nearness of the Un-Saturated Hydro Carbon securities exists in the Biodiesel.

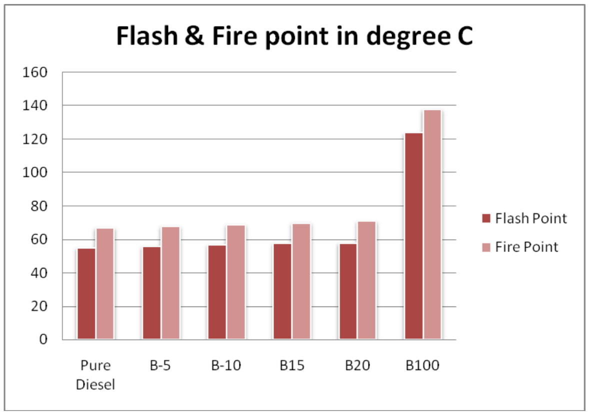

Fig -3: **Variation in the Flash & Fire Point of the different Blends**

The Engine which is should have been tried is accessible in the Energy lab, which is carefully worked. Thus IC Engine Software is introduced to it which is called as "ENGINE SOFT", to measure the Performance, Emission & Combustion analysis. The Following is the Detail of the Diesel Engine as shown in the following Table -1

Table -1: Engine Setup

Sl. No.	ENGINE PARAMETERS	SPECIFICATION
1	Manufacturer	Kiloskar
2	Stroke	4
3	No. of cylinder	1
4	Stroke length(L)	110mm
5	Bore diameter (D)	87.5mm
6	Rated Power	3.5 kW at 1500rpm
7	Diameter of orifice	20mm
8	Length of Connecting Rod	234 mm
9	Compression Ratio	12 to 18

III EXPERIMENTAL SETUP

The Diesel Engine will be Engine is associated with the Computer, the Software "ENGINE SOFT" installed in it, introduced in it, to record the Combustion and Performance Data through this product. The Setup Experiment is appeared in Figure underneath.

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Fig -4: IC Engine Setup

Engine is linked to the Sensor which is connected to the Control System. In the Exhaust Manifold connected to the Exhaust Gas Tester (Gas Analyzer) probe to measure the Exhaust gas contents. Due to the variation in the load the fuel is supplied in the Fuel Burette (average Fuel Tank). The Performance like (BTE BSFC & Mech. Eff.) & Combustion parameters (Rate of Pressure Rise Net Heat Transfer & Cumulative Heat Transfer) is obtained by the IC Enginesoft software. And the Exhaust Parameters (HC Emission, O_2, CO_2, CO & NOx) are obtained by the Exhaust Gas Analyzer Tester. And the final Results were plotted for different blends of the KOME & Diesel Fuel. The capacity of diesel Engine is 12 kg (3.5 kW).

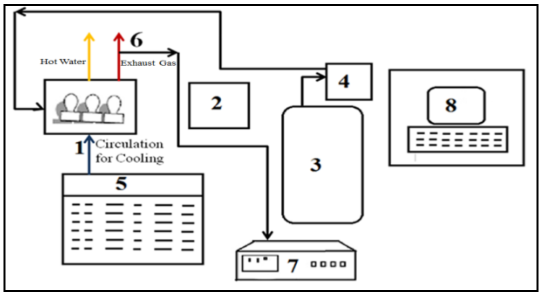

Fig -5: Block Diagram for the IC Engine Setup

Table - 2: Engine Setup

Sl. No.	**Description**
1	Single Cylinder 4-Stroke CI Engine
2	Dynamometer

3	Engine Load Regulator
4	Fuel Tank
5	Water Storage
6	Exhaust Manifold
7	Gas Analyzer
8	Control System (Computer)

IV RESULTS & DISCUSSION

4.1 Performance Parameters

4.1.1 Load % Vs. Brake Thermal Efficiency (BTE):

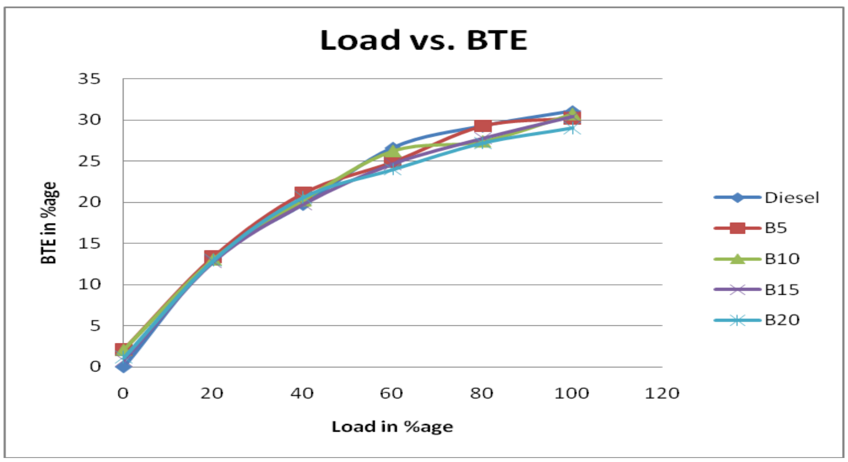

Fig -6: Variation of the Brake thermal Efficiency with Load

The Fig shows the difference of the BTE with respect to load proportion for KOME biodiesel Blends and pure diesel, the load variation is according to the Table 4. Brake thermal efficiency increases with increasing Load. It is due to decrease in heat loss & output Power increases [10]. At full load condition, BTE values are 31.06, 30.21, 30.69, 30.45 & 29.05 for the Diesel fuel, B5, B10, B15 & B20 respectively. Lower Calorific Value of the KOME blend tends to decrease in the Brake Thermal Efficiency [3]. And also possible reason is due to increase in viscosity, volatility & delay in air-fuel mixing rates for the KOME blends the leads to decrease in BTE[13].

4.1.2 Load Vs. Brake Specific Fuel Consumption

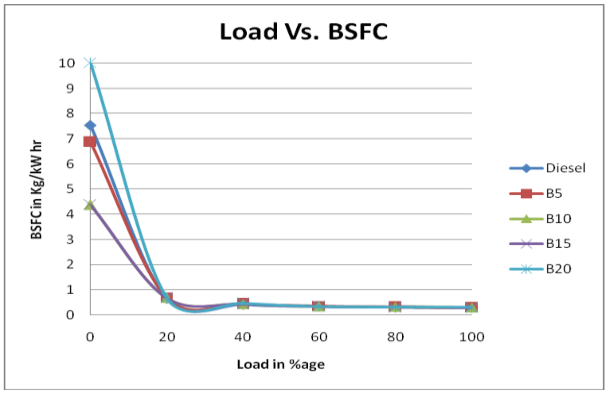

Fig -7: Variation of the BSFC with Load

The above Fig -7 shows the variation of the BSFC of Different blends of KOME & Pure Diesel at variable Load Condition. Due to incomplete combustion in the lower loading conditions, less Power is developed and requires extra air and fuel mixture to develop the power. It is observed from the above graph that the BSFC for KMOE20 is more as compared to that of pure diesel due to low calorific value [1], but the increase in the BSFC is not appreciable, it is due to the accessibility of the oxygen in the blends of KOME may be the cause for the almost similar BSFC [3].The value of BSFC for Pure Diesel is 0.29 Kg/kW hr where as for B20 KOME is 0.31 Kg/kW hr at full load condition, So there is only 3.33% of increase in the BSFC for the B20 Blend. Due to lesser calorific value of the fuel and engine utilizes additional quantity of the fuel in turn to generate output Power.

4.1.3 Load Vs. Exhaust Gas

Temperature

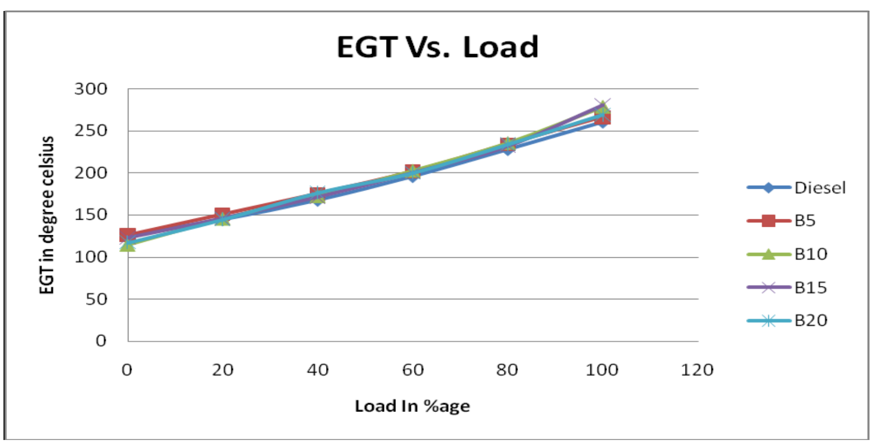

Fig -8: Variation of the EGT with Load

The above Fig - 8 shows the nature variation of the EGT at variable engine load conditions for the KOME blends and pure diesel. The difference value obtained in EGT was form 115° C to 280°C. if the load is increased from 0 to 100%. The increase in EGT with respect to the load is clear from the fact that more content of fuel is required at higher load to develop more amount Power. The EGT for the diesel was found to be 260°C where as for the B15 was Maximum of 280°C. For the B20 KOME biodiesel Blend EGT is 269°C, hence there is increase in 7.7% of EGT for B20 W.R.T to pure diesel. Combustion occurs at the later part and heat is released after the combustion process [5].

4.1.4 Load Vs. Mechanical Efficiency

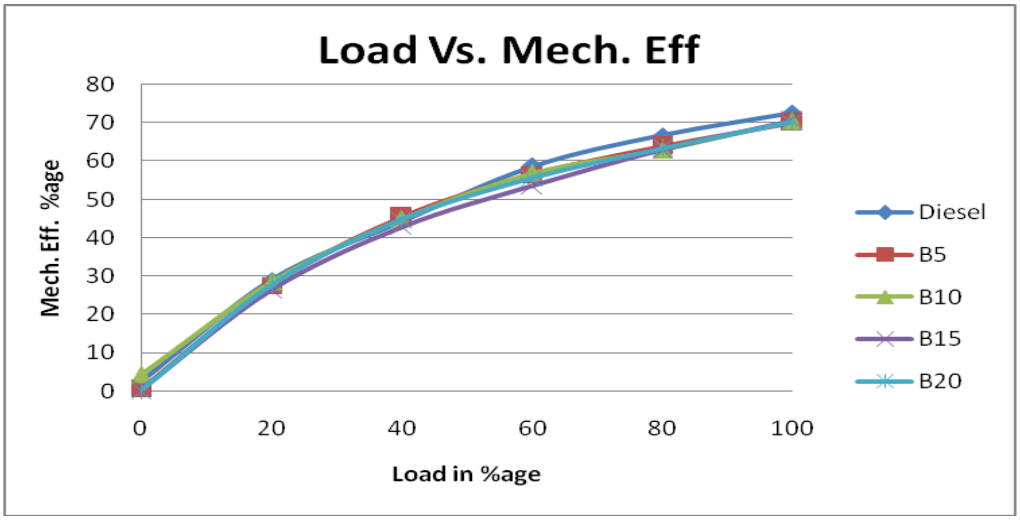

Fig -9: Variation of the Mechanical Efficiency with Load

The above Fig -9 shows the variation of the Mechanical Efficiency at different engine load conditions for the KOME blends & pure diesel. The Mechanical Efficiency is referred as the Output Power generated at the Crankshaft to the Power generated at the cylinder after the combustion of fuel. From the above graph, the similar nature of curve is generated for all the KOME blends and for the pure diesel. It is obvious that, as the load increases the Mechanical Efficiency also increases, because of the ability to develop the power in engine is also increases. And heat losses are going to be reduced [10]. At Full Load condition, The Mechanical Efficiency for the Pure Diesel, B5, B10, B15 and B20 is 72.5, 70.06, 70.51, 70.71 & 70.26 respectively. For Diesel, due to more heating value of the fuel more Power is developed in the Engine. So the Mechanical Efficiency for the Diesel is more compared to the KOME blends, but is not appreciable, it is due to the Lubrication provided in the Piston & Cylinder wall by the Blends. It has been seen that the Mechanical Efficiency is more in the B30 compared to the Pure Diesel & other Blends [10].

4.2 Combustion Parameters

4.2.1 Crank Angle Vs. Pressure Variation

For the CI engine, when fuel is injected inside the cylinder, it takes time to become fine droplets, decomposes and then mixes with the air uniformly to make a combustible mixture. The pressure is due to the rate of fuel burning in the premixed burning phase.

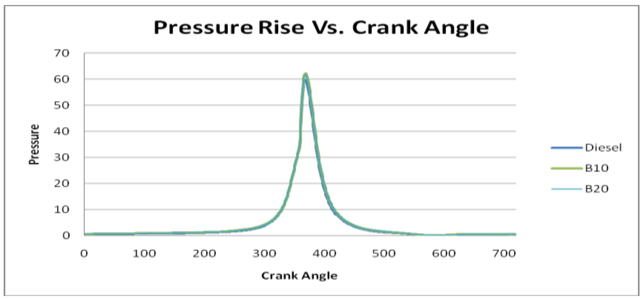

Fig - 10: **Variation of the Pressure with Crank Angle**

The above Fig shows the variation of Pressure rise against crank angle for pure diesel & the KOME blends during the full load condition. From the Fig no 10, it is clear that the peak cylinder pressure is reduced with the increase in addition of the KOME blends. Nonetheless, the combustion process of the test fuels is similar, consists of a premixed combustion phase followed by diffusion phase (mixed combustion). Premixed combustion phase is regulated through ignition delay period and spray envelope of the introduced fuel. Due to this reason the combustion of the diesel fuel occurs early compared to the blends. Hence, Viscosity and volatile nature of the fuel have very significant part to increase atomization rate and to enhance air-fuel entrapment. The cylinder peak pressure is slightly higher for KOME blends than that of pure diesel, because KOME biodiesel blends has high viscous and low volatile nature. And the peak value of the pressure shift towards the right side for the blends. Hence the Peak Pressure is slightly on the higher side. The Peak pressure is 59.73 bar, 62.8 bar & 61.58 bar for Diesel, B10 & B20 respectively.

4.2.2 Crank Angle Vs. Net Heat Release (NHR)

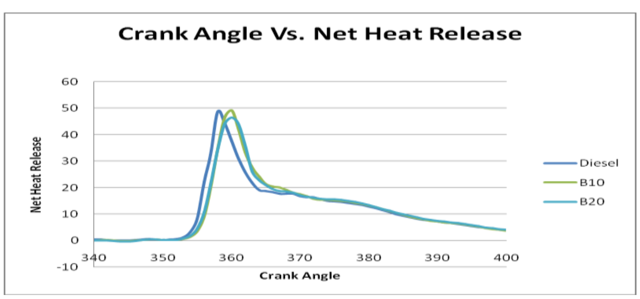

Fig - 11: Variation of the NHR with Crank Angle

The Fig-11 shows the variation of heat release rate with crank angle at full load for the pure diesel & the KOME blends. From the above Fig, the rate of Net Heat Release for the pure diesel (B0) is more & reduces for the KOME biodiesel blends. This may be due to non-viscous and better atomization property of diesel fuel (higher hydrocarbon fraction for the diesel fuel) as compared to the B10 & B20 [15]. The Peak Heat release values are 48.62 at 358°, 49.23 at 360° & 46.52 J/Degree at 361° for Diesel fuel, B10 & B20 respectively. The peak value is Maximum for B10 with respect to the diesel fuel. This is due increased delay period of fuel during the relatively longer delay period caused in higher rate of heat release. On the other hand, the peak heat release rate is lower for B20with respect to B10 and pure diesel. This may be due to the lower volatile, high temperature flash point and higher viscosity of KOME blends, that leads to a reduction in fuel-air mixing ratio, causing in smaller content of fuel is ready for premixed combustion stage after ignition delay [15].It can also be witnessed that the diffusion burning indicated by the area under second peak is dominant for B20. This may be due to the complete combustion occurs at the late combustion phase. Hence for the B20 Heat release is increased at End of the Power Stroke.

4.4 Emission Parameters

4.3.1 Load Vs. CO Emission

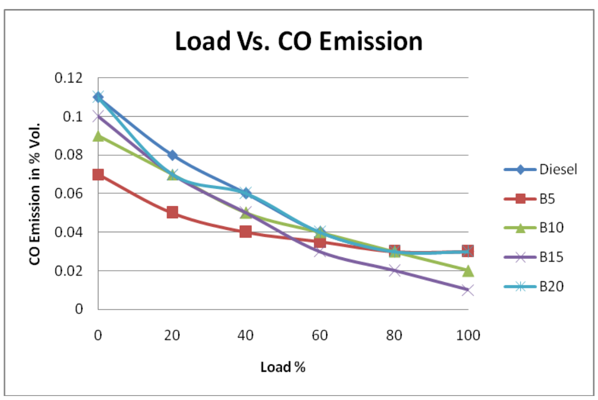

Fig -12: Variation of the Emission of CO with Load

The above Fig -12 shows the variation of the CO emission for different blends of KOME & pure diesel at variable load condition. The CO formation refers to the incomplete combustion in the Engine Cycle. At the Higher Loads, more the Power is developed in the engine. Hence there is decrease in the traces of CO emission percentage due to the complete combustion. The Variation of the CO emission for the KOME blends is less at the lower Loads, because of the Oxygen atoms [12].At the higher loads, the CO emission for KOME B15 is minimal value.

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4.3.2 Load Vs. HC Emission

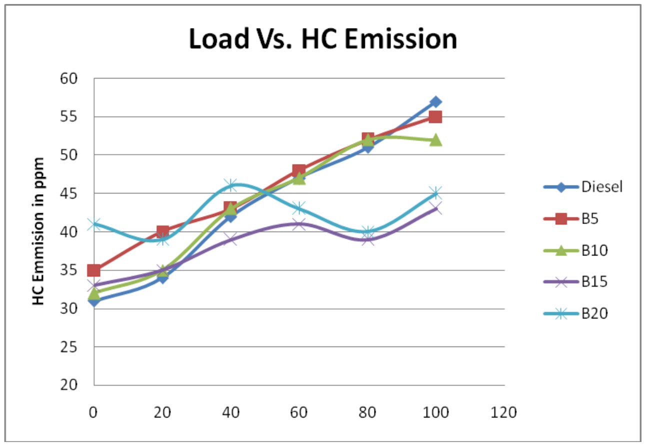

Fig -13: Variation of the Emission of HC with Load

The above Fig-13 shows the variation of the HC emission of Different Blends OF KOME & Pure diesel at variable load condition. The Hydrocarbons (HC) Emissions is very harmful to the environment. HC emission is due to the unburnt in-complete combustion of Carbon-Hydrogen compounds in the fuel. HC emission is increased if the load is increased, because of the more availability of the fuel in the combustion chamber at different location. So there is a chance of incomplete burning of the fuel at the different regions of the combustion chamber. The value of HC emission decreases with increase in quantity of KOME blends. This may be due to the availability of the oxygen atoms & lesser CH bonds in the KOME Blends helpful for the complete burning of the fuel and emits lesser amount of HC [1] & [13].

4.3.3 Load Vs.CO_2 Emission

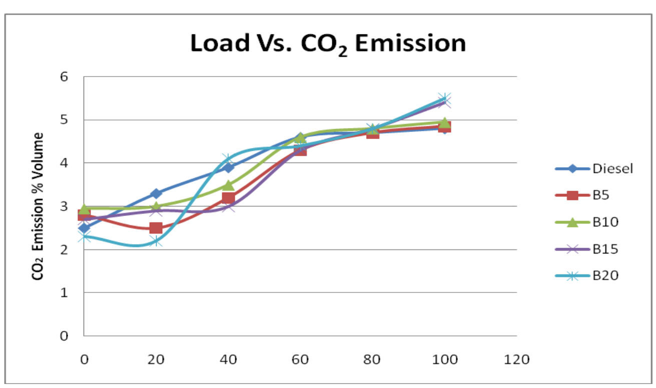

Fig -14: Variation of the Emission of CO_2 with Load

The above Fig shows the variation of the CO_2 Emission of Different Blends of KOME blends & pure diesel at variable load Condition. The Emission of the CO_2 is because of the fuel is undergoing complete combustion. Hence, more amount of the Power in generated after fuel is burnt completely. At higher load, the requirement to develop the Power in engine is increases, thus the fuel undergoes complete Combustion. From above Fig -14, CO_2 emission is higher for the due to the oxygen content in the KOME blends as compared the diesel fuel. And diesel has a lower elemental carbon to hydrogen ratio as compared to the KOME blends [14]. So emission of CO_2 is more in KOME Blends as compared to the pure diesel fuel.

4.3.4 Load Vs.NOx Emission

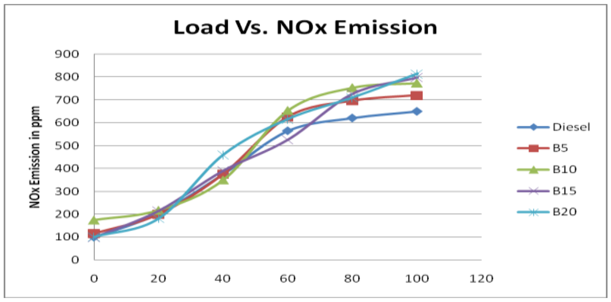

Fig -15: Variation of the Emission of NOx with Load

The above Fig shows the variation of the NOx Emission of different blends of KOME & Pure Diesel at variable load condition. Temperature & Oxygen are two main factors of the NOx Emission in the engine . Due to increase in the loading, in order to develop more amount of the Power, the temperature inside the cylinder increases due to combustion of the more amount of fuel. As we can see in Fig-8, the Exhaust Gas Temperature is maximum during the Power stroke leads to increase in NOx. For KOME blends, due to availability of the unsaturated Hydrocarbon, there is delay in the ignition of the fuel. So the Power is developed just at the later stage, which results higher temperature. And this phenomena supports for the emission of more amount NOx. And also the due to the traces of oxygen present in the in the KOME blends, there will be possibility of more NOx Emission, as the traces Oxygen reacts with Nitrogen and form Nitrous Oxide & Nitric oxide at higher temperature. At the full load condition, the NOx for the B20 is 814 ppm where as for the Pure Diesel is 650ppm. From the above graph the NOx Emission will increases with increase in the proportion KOME blend in fuel.

VI CONCLUSIONS

In this paper, the experimental work on a one cylinder Four stroke Diesel Engine utilizing biodiesel got from Karanja Oil named as the Karanja Oil Methyl Ester (KOME) Biodiesel as a substitute fuel. The conclusions were drawn from this investigation are recorded underneath.

- The brake thermal efficiency of the engine with the blends of the KOME blend was slightly lesser than that of neat diesel fuel.
- The Brake Specific Fuel Consumption (BSFC) for the Diesel is marginally less than the KOME blends.
- Exhaust Gas Temperature (EGT) for is found to increase with concentration of KOME in the fuel blend with respect to the pure diesel due to poor atomization and overdue (delay) combustion. For the B15 the EGT is found out to be Maximum.
- The Pressure variation with the crank angle will be steeper for the Diesel and peak value gets shifted towards the right side for the Blends due to the delay period of the Ignition and due to high heat release rate in the premixed combustion, the Pressure will be marginally higher side for the blends.
- The Carbon monoxide (CO) emission refers to the incomplete burning of the fuel mixture inside the combustion chamber. The Carbon monoxide (CO) emissions were less in case of KOME concentration compared with the pure diesel.
- The Hydrocarbons (HC) Emissions is very harmful to the Environment. The results have been obtained that there is decrease in the emission of HC for the KOME blends compared as along with the pure diesel.
- The emission of the Carbon dioxide refers to the complete burning of the fuel mixture. From the above results the CO2 emission is high for the KOME blends compared to the Pure Diesel.
- The NOx emission considered to be one of the high toxicants emitted by engines in to the Environment. Due to the availability of the traces oxygen compound, emission of the NOx concentration increases with increase in the proportion of the KOME blends compared to that of pure diesel.
- The Biodiesel production can be done locally, Rural & the areas where the less rain is showered. By producing biodiesel in the draught affected regions, we can reduce our unemployment in the local region. From all these results, the range of B10 to B20 is considered to be the better fuel. Hence Biodiesel made with Karanja Oil is fairly suitable as an alternative fuel to the pure diesel fuel.

REFERENCES

[1] L. Karikalan and M. Chandrasekaran “Karanja Oil Biodiesel: A Potential Substitution For Diesel Fuel In Diesel Engine Without Alteration”ARPN Journal of Engineering and Applied Sciences, VOL. 10, NO. 1, JANUARY 2015

[2] Nagarhalli M. V, Nandedkar V. M and Mohite K.C “Emission and Performance characteristics of Karanja biodiesel and its blends in a C.I. Engine and it’s Economics”, ISRN Renewable Energy, 5402/2012/621518 Sep 17, 2014

[3] P.L. Naik, D. C. Katpatal “Performance Analysis of CI Engine using PongamiaPinnata (Karanja) Biodiesel as an Alternative Fuel”, IJSR, Volume 2 Issue 8 August 2013

[4] R.S.Kureel, C.B.Singh, A.K.Gupta & AshutoshPandey "Karanja a Potential Source of Bio-Diesel, (NOVOD) Board, 2008."

[5] Bobade S.N. and Khyade V.B. "Detail study on the Properties of Pongamia Pinnata (Karanja) for the Production of Biofuel" Research Journal of Chemical Sciences, Vol. 2(7), 16-20, July (2012)

[6] R. Prakash, R. K. Singh, S. Murugan "Performance and Emission Studies in a Diesel Engine Using Bio Oil-Diesel Blends" Second International Conference on Environmental Science and Technology (ICEST 2011), February 26-28.2011, Singapore.

[7] V. Ganeshan "Internal Combustion Engine"

[8] Pavan Pujar & B. K. Venkanna "Production and characterization of biodiesel from Mackerel fish oil" International Journal of Scientific & Engineering Research(IJSER) , Volume 5, Issue 11, November-2014

[9] Ravi. S. D, S. R. Hotti & Dr. O. D. Hebbal "Performance, Combustion and Emission Characteristics on Single Cylinder Diesel Engine using Calophyllum Inophyllum (Surahonne) Oil"International Journal of Engineering Research & Technology (IJERT),Vol. 3, Issue 9,September- 2014,ISSN: 2278-0181.

[10] Ganesh Singh Chauhan, Abhishek Chakraborty & Dr. Rashmi Shah "Experimentation on Chemical Feasibility of Karanja Seed Oil to Use as In Diesel Engines Using 4-Stroke Single Cylinder Diesel Engine Test Rig" International Journal of Engineering Research and Applications (IJERA) , Volume 3 Issue 4, Jul-Aug 2013

[11] Pavan Pujar, B. K. Venkanna, Basavaraj Mudhol, Pavan Kulkarni "Performance characteristics of direct injection diesel engine running on Mackerel fish oil biodiesel / diesel fuel blend" International Journal of Scientific & Engineering Research, Volume 6, Issue 1, January-2015

[12] Baste S.V., Bhonsale A.V. and Chavan S.B. "Emission Characteristics of Pongamia Pinnata (Karanja) Biodiesel and Its Blending up to 100% in a C.I. Engine", International Journal of Engineering Research & Technology, Vol. 3 - Issue 8 (August - 2014).

[13] Puneet Verma, M.P. Sharma, Gaurav Dwivedi "Operational and Environmental Impact of Biodiesel on Engine Performance: A review of Literature" INTERNATIONAL JOURNAL of RENEWABLE ENERGY RESEARCH P.Verma et al., Vol.5, No.4, 2015.

[14] Taranjot Singh, Dr.Vineet Kumar "Experimental Investigation on the Performance And Emission Characteristics Of Mahua Biodiesel In Single Cylinder Di Engine" ISSN: 2320-2491.

[15] Suraj Bhan Singh, Atul Dhar, Avinash Kumar Agarwal "Technical Feasibility Study of Butanol-Gasoline 1 Blends for Powering Medium-Duty 2 Transportation Spark Ignition Engine" Indian Institute of Technology Kanpur.