

# **Comparative Evaluation of CI Engine Performance and Emission Characteristics Using Preheated Karanja Oil Blends and Its Corresponding Biodiesel Blend**

Runjun Saikia <sup>1</sup>

Lecturer, Department of Mechanical Engineering, Sibsagar Polytechnic, Demow, Assam, India<sup>1</sup>

**ABSTRACT:** In the present investigation experimental work has been carried out in a stationary, single cylinder, water cooled diesel engine at various engine loads. In this experimental study, performance and emission characteristics of CI engine run on various preheated blends of Karanja oil, are critically analyzed against the performance with 20% Karanja biodiesel blend to evaluate the most suited blending ratio and the preheated temperature level. Initially 10%, 20% and 30% blend of karanja oil with diesel has been prepared and are heated, using a heating mantle, to temperatures of 30<sup>o</sup>C, 40<sup>o</sup>C, 50<sup>o</sup>C and 60<sup>o</sup>C from ambient temperature of 26<sup>o</sup>C. For comparison purpose, mineral diesel at ambient condition as fuel has also been considered. Experimental results show that with increase in degree of preheating of karanja oil blends, the Brake Thermal Efficiency (BTE) and Brake Specific Energy Consumption (BSEC) get improved, CO, HC emissions get reduced and NO<sub>x</sub> emission get increased. Considering mineral diesel, KB20 blend, and all KO blends (with and without preheating), the KO10 blend preheated up to 60<sup>o</sup>C is found to have superior performance and lower overall emissions followed by KO20 blend at the same preheated temperature. KO20 blend at 60<sup>o</sup>C performs better than KB20 and emissions are almost similar to KB20. Although KO20 is slightly inferior to KO10, considering the fact of more diesels saving in KO20, KO20 at 60<sup>o</sup>C may be considered to be the most suitable fuel blend which is evolved as a better choice than KB20.

**KEYWORDS:** Blending ratio, Diesel Engine, Karanja Biodiesel, Karanja Oil, Preheated Temperature.

## **I. INTRODUCTION**

Depletion of fossil fuels and continuous increment of petroleum prices have prompted the interest towards the use of inedible vegetable oils as alternate source of fuel for diesel engines. Vegetable oils are renewable in nature and significant environmental benefit can be derived from the combustion of vegetable oil. Studies involving the use of raw vegetable oils as a replacement for diesel fuel indicate that a diesel engine can be successfully fuelled with 100% vegetable oil on a short-term basis. However, long-term engine durability studies show that fuelling diesel engines with 100% vegetable oil causes engine failure due to engine oil contamination, stuck piston rings, and excessive carbon build-up on internal engine components. Short-term engine testing indicates that vegetable oils can readily be used as a fuel source when the vegetable oils are used alone or are blended with diesel fuel [1]. But if greater blend ratio of the oil and its long-term use is required, modification of the properties of the vegetable oil has to be done. Researchers have suggested different techniques for reducing the viscosity of vegetable oil, which are dilution/blending, heating/pyrolysis, micro-emulsification and transesterification. However, transesterification process of obtaining biodiesel is a more expensive, time consuming and complex process due to the chemical and mechanical processes involved. Emulsions can be made by mixing water and surfactants with oil in a simple process. However, making stable emulsions with suitable surfactants is a difficult task. In addition to that use of emulsions in diesel engines results in inferior performance at part loads [2]. Preheating of vegetable oil blends is one of the viable solutions of the problem. Preheating is done to obtain the properties of vegetable oil mainly viscosity and density close to that of diesel.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 8, August 2017

## II. RELATED WORK

Researchers are trying to find several ways to make use of vegetable oil as alternate fuel source for diesel engine and are trying to find performance & emission characteristics of the CI engine at various conditions as described below:

Pryor et al. [3] conducted short and long-term engine performance tests using 100% soybean oil in a small diesel engine. Short-term test results indicated the performance of soybean equivalent to that of diesel fuel. However, long-term engine testing was aborted due to power loss and carbons build up on the injectors. Pryde et al. [4] reviewed the reported successes and shortcomings for alternative fuel research. This article stated that short-term engine tests using vegetable oils as a fuel source was very promising. However, long-term engine test results showed that durability problems were encountered with vegetable oils because of carbon build up and lubricating oil contamination. Thus, it was concluded that vegetable oils must either be chemically altered or blended with diesel fuel to prevent premature engine failure.

Bajpai et al. [5] in their experiments with blends of karanja in a direct injection engine found that BTE improved slightly at lower engine loads compared to that of mineral diesel. The BTE curve in case of 10% karanja oil blend was higher at full load as compared to mineral diesel. BTE was reduced at higher loads for all other blends as compared to mineral diesel. BSFC increased slightly for all blends as compared to neat diesel. BSEC was slightly higher for neat diesel at lower loads and remained the same at higher loads for 5%, 10%, 15% and 20% karanja vegetable oil (KVO). The smoke was significantly reduced for all blends as compared to neat petroleum based diesel fuel. CO emission for KVO5, KVO10, and KVO20 were less than the diesel over the entire range of load. Greenhouse emissions, like CO<sub>2</sub> emission, showed about a 5% reduction for all blends as compared to neat petroleum based diesel fuel. KVO10 gave relatively lower HC as compared to neat diesel up to a 70% load. However, HC emission was higher for the case of all KVO blends as compared to mineral diesel after 70% load. KVO5 showed lower HC over the entire range of engine operation. NO<sub>x</sub> emissions for the case of KVO blends were lower at 100% load. KVO20 blend gave around 4% lower NO<sub>x</sub> emissions at 80% load as compared to mineral diesel.

Chauhan et al. [6] evaluated the suitability of *Jatropha curcas* oil (unheated and preheated) as an extended fuel for CI engine. Experimental results show that the engine performance with unheated *Jatropha* oil is slightly inferior to the performance with diesel fuel. As fuel inlet temperature of *Jatropha* oil increased, viscosity decreased and the engine performance improved. BTE of the engine was lower and BSEC consumption of the engine was higher when engine was fuelled with unheated *Jatropha* oil compared to diesel fuel. However, in case of preheated *Jatropha* oil, these parameters were superior to unheated *Jatropha* oil. NO<sub>x</sub> from *Jatropha* oil during the whole range of experiment were lower than diesel fuel. However, for preheated *Jatropha* oil, NO<sub>x</sub> emissions were increased. CO, HC, CO<sub>2</sub> emissions from unheated *Jatropha* oil were found higher than diesel fuel during the whole experimental range. With preheated *Jatropha* oil, the value of CO, HC and smoke opacity was decreased and CO<sub>2</sub> emissions were slightly increased. Result shows that at 100<sup>o</sup>C of fuel inlet temperature of *Jatropha* oil, performance and emissions were favourable but leakage of lube oil from the engine occurred. Therefore, 80<sup>o</sup>C was evaluated as the optimal fuel inlet temperature, considering the BTE, BSEC and gaseous emissions and durability and safe operation of the engine. Kadu et al. [7] used preheated neat karanja oil in a four stroke, single cylinder diesel engine. Preheating was done from 30<sup>o</sup>C to 100<sup>o</sup>C. They have found that at higher speed there was no significant difference in BSFC when the engine was operated with preheated and unheated vegetable oil fuels. In other words, BSFC is not affected due to temperature of fuel at inlet conditions. The karanja oil fuel produced the same BTE at high speed and low speed of the engine and slightly deviating in the mid of the speed range studied. The heated fuel showed a marginal decrease in BTE efficiency as compared to diesel fuel operation. Engine power increases with speed to a maximum value at an engine speed of 3500 rpm. At speeds more than 3500 rpm the power produced is slightly higher than that of ordinary diesel fuel. This clearly indicates that at higher engine speed conditions the performance of karanja oil fuel can exceed that of diesel fuel operation. There was significant increase in NO<sub>x</sub> emissions when running on neat karanja oil compared to diesel fuel operation. The overall test results showed that fuel heating was not beneficial at low speed operation.

Based on the above comprehensive literature study, Preheating can offer significant reduction in viscosity with improved performance and reduced emissions. Specific energy consumption is reduced when preheated fuel is used. The most of the emission like CO, HC, and smoke are reduced when the vegetable oils are preheated compared to the unheated raw vegetable oil although the level of emissions is slightly higher compared to diesel [8]. But if the fuel is

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 8, August 2017

heated up to a maximum temperature then the emissions is somewhat lower than that of diesel. NO<sub>x</sub> emission increases with preheating and in certain cases there may be slight increase in CO<sub>2</sub> emission. However, the fuel injection system is made up of parts that are very close fitting, such as the plunger–barrel assembly. High fuel intake temperature may have adverse effects on these closefitting parts since diesel engines normally run with fuel supplied at ambient temperature. Consequently, vegetable oil needs to be heated to a temperature that is high enough to give a low viscosity similar to diesels, but not so high as to damage the injection system [9]. Moreover, if heated to very high temperatures, low viscosity of the fuel can result in poor fuel droplet penetration and poor combustion.

Considering the maximum allowable preheating temperature of vegetable oil blends, it is difficult to obtain the performance and emission characteristics of preheated vegetable oil blends comparable to that of mineral diesel. Hence, in the present work experimental investigation has been carried out to ascertain the most efficient preheating temperature and blending ratio of Karanja oil blend with diesel which would provide the similar performance and emission characteristics as that of 20% karanja biodiesel blend with diesel, which has already been established. This paper investigate the scope of utilizing preheated Karanja oil blend instead of transesterified Karanja biodiesel blend which is more expensive and complex process is involved in transesterification of biodiesel.

### III. EXPERIMENTAL SET-UP

The feasibility of any type of fuel to an engine is first evaluated by its characterization, performance in the engine and the corresponding emissions of the fuel through experimentation.



Figure 1: Test Engine Setup

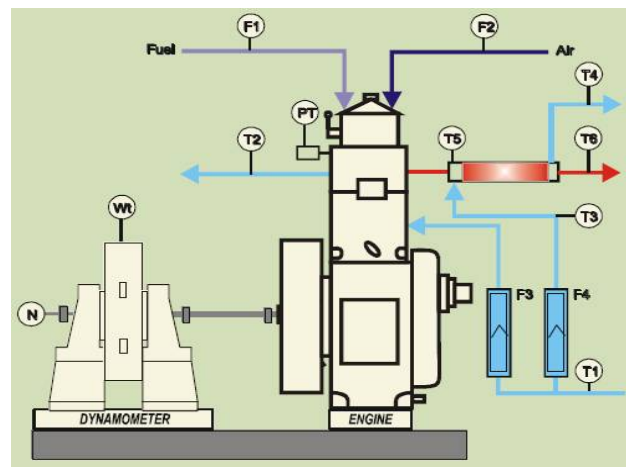


Figure 2: Schematic Arrangement of the Engine Test Rig

The setup is shown in Figure 1 and Figure 2. It consists of single cylinder, four strokes, multi-fuel, variable compression ratio (VCR) diesel engine connected to eddy current type dynamometer for loading.

- F1 Fuel consumption
- F2 Air consumption
- F4 Calorimeter water flow
- T1 Water inlet temperature to engine
- T2 Water outlet temperature from engine
- T3 Calorimeter water inlet temperature
- T4 Calorimeter water outlet temperature
- T5 Exhaust gas inlet temperature to calorimeter
- T6 Exhaust gas outlet temperature from calorimeter

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

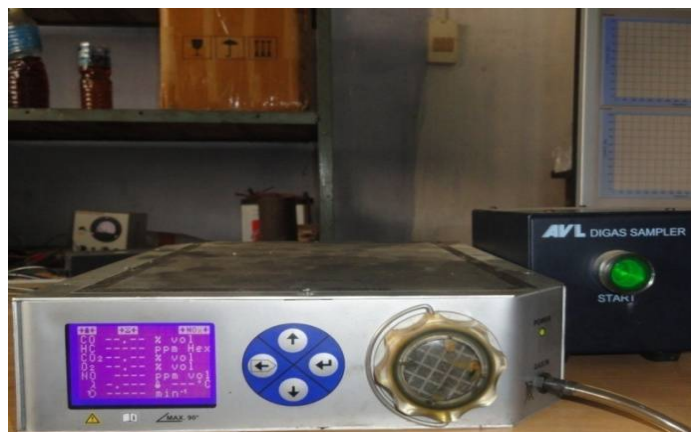
Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 8, August 2017

The setup enables study of VCR engine performance for brake power (BP), indicated power (IP), frictional power (FP), brake mean effective pressure (BMEP), indicated mean effective pressure (IMEP), brake thermal efficiency (BTE), indicated thermal efficiency (ITE), mechanical efficiency, volumetric efficiency, specific fuel consumption (SFC), A/F ratio, heat balance and combustion analysis. Lab view based engine performance analysis software package “Engine soft” is provided for on line performance evaluation. The detailed specification of the engine is given in Table 1.

**Table 1:** Specifications of the Diesel Engine

Make	Kirloskar
Mode	TV1
Rated Brake Power (bhp/kw)	7/5.2
Rated Speed(rpm)	1500 rpm
Number of Cylinder	Single Cylinder
Bore X Stroke(mm <sup>2</sup> )	87.5 mm X 110 mm
Compression Ratio	17.5
Cooling System	Water-cooled
Lubricating System	Forced feed system
Cubic Capacity	0.661 liters
Inlet Valve open(Degree)	4.5 degree before TDC
Inlet Valve closed(Degree)	35.5 degree after BDC
Exhaust Valve open(Degree)	35.5 degree before BDC
Exhaust Valve closed(Degree)	4.5 degree after TDC
Fuel Injection Timing(Degree)	23 degree before TDC



**Figure 3:** Gas Analyser

The various gas emissions like CO, HC, NOX, O2 and CO2 are measured using AVL DIGAS444 analyzer. The probe of the analyzer is fitted into the exhaust pipe extension specially designed for the purpose. Figure 3 shows the gas analyzer and the measuring ranges of the gas analyzer are given in Table 2.

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 8, August 2017

**Table 2:** Measuring range of Gas Analyser

Measuring Quality	Measuring range
CO	0- 10%
CO <sub>2</sub>	0-20%
HC	0-20000 ppm
O <sub>2</sub>	0-22%
NO <sub>x</sub>	0-5000 ppm

A heating mantle is used for the purpose of heating the karanja oil blends. It is an aluminium cast body and is made out of oxidised Nichrome wire with ceramic bead and sleeving. There is an energy regulator for positive control of temperature. Energy regulators acts as simerstat and regulate the power to the heater.

Technical Data of the heating mantle is shown below:

Capacity: 1 Litter.

Temperature control: Energy regulator.

Heater: 300 W.

Power supply: 230 V, 1 Phase, 50 Hz.



**Figure.4:** Heating Mantle (WIL - 141)

The heating mantle which is used in our experimentation is shown in Figure 4.



# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 8, August 2017

## IV. EXPERIMENTATION

The experimentation required to be carried out for this present work can be divided into three groups: Fuel characterization, engine performance tests and emission measurements. The fuels (karanja SVO, karanja biodiesel and diesel) were analyzed for several physical, chemical and thermal properties and results are shown in Table.3.

**Table 3:** Properties of Diesel, Karanja Biodiesel and Karanja SVO

Property	Diesel	Karanja Biodiesel	Karanja SVO
Density(kg/m <sup>3</sup> )	840	882	933.2
Kinematic viscosity at 40 <sup>0</sup> C(cst)	2.763	4.953	36.59
Property	Diesel	Karanja Biodiesel	Karanja SVO
Cloud point( <sup>0</sup> C)	1 <sup>0</sup> C	8 <sup>0</sup> C	9 <sup>0</sup> C
Pour point( <sup>0</sup> C)	-8.5 <sup>0</sup> C	4 <sup>0</sup> C	6 <sup>0</sup> C
Flash point( <sup>0</sup> C)	72	152	232
Copper corrosion	Freshly polished	Slight tarnish 1b	Slight tarnish 1a
Carbon residue(% ,w/w)	0.1	0.32	0.46
Calorific value(kJ/kg)	42000	36120	34000

Viscosity and density of the heated blends of karanja oil and 20% karanja biodiesel blend are measured and the results are shown in Table 4.

**Table 4:** Viscosity and Density of the Blends of Karanja SVO and 20% Karanja Biodiesel Blend

Blend	Property	Karanja SVO					Karanja Biodiesel
		Temperature( <sup>0</sup> C)					Temperature( <sup>0</sup> C)
		26	30	40	50	60	26
10%	Kinematic viscosity(cst)	4.906	3.972	3.2	2.732	2.088	-
	Density(kg/m <sup>3</sup> )	846.1	841.1	833.2	827.6	820.8	-
20%	Kinematic viscosity(cst)	6.647	4.91	3.907	3.18	2.78	4.735
	Density(kg/m <sup>3</sup> )	857.1	850	844	838	831	845.8
30%	Kinematic viscosity(cst)	8.721	6.712	5.412	4.815	3.481	-
	Density(kg/m <sup>3</sup> )	862	859	853	848	841	-

## V. EXPERIMENTAL RESULTS & DISCUSSION

### 5.1 ENGINE PERFORMANCE RESULTS

The experiments are carried out using the three different blends (KO10, KO20, KO30) of karanja oil with diesel at 26<sup>0</sup>C, 30<sup>0</sup>C, 40<sup>0</sup>C, 50<sup>0</sup>C, 60<sup>0</sup>C, karanja biodiesel blend (KB20) with diesel and 100% diesel fuel. KB20 and diesel fuel are considered at ambient temperature of 26<sup>0</sup>C. The results obtained in terms of engine performance parameters like Brake Thermal Efficiency (BTE), Brake Specific Energy Consumption (BSEC), and Exhaust Gas Temperature (EGT) are described in the following subsections.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 8, August 2017

## 5.1.1 BRAKE THERMAL EFFICIENCY (BTE)

It is observed from the Figure 5 that BTE increases with increase in load up to about 90% loading and then decreases up to 100% loading. This is due to reduction in heat loss and increase in power with increase in load. The 90% loading condition is selected based on the fact that the BTE is highest at this loading condition.

At 50°C, density and viscosity of KO10 decreases to a lower value and it improves the fuel spray characteristics and fuel droplets get atomized properly. As a result, it improves combustion phenomenon. Moreover, calorific value of KO10 is higher than KB20 which ultimately results in marginal increase of BTE of KO10 over KB20. But in case of diesel, it's very high calorific value is predominant over the decrease in density and viscosity of KO10. Therefore, BTE of diesel is more than KO10. Decrease in density and viscosity of KO20 at this temperature is only marginally less than KB20 and hence higher calorific value and lower ignition delay of KB20 is predominant over this decrease of density and viscosity. Therefore, BTE of KO20 is marginally less than KB20. BTE of KO30 is lowest amongst all the considered SVO blends because of its high viscosity, high density and low calorific value.

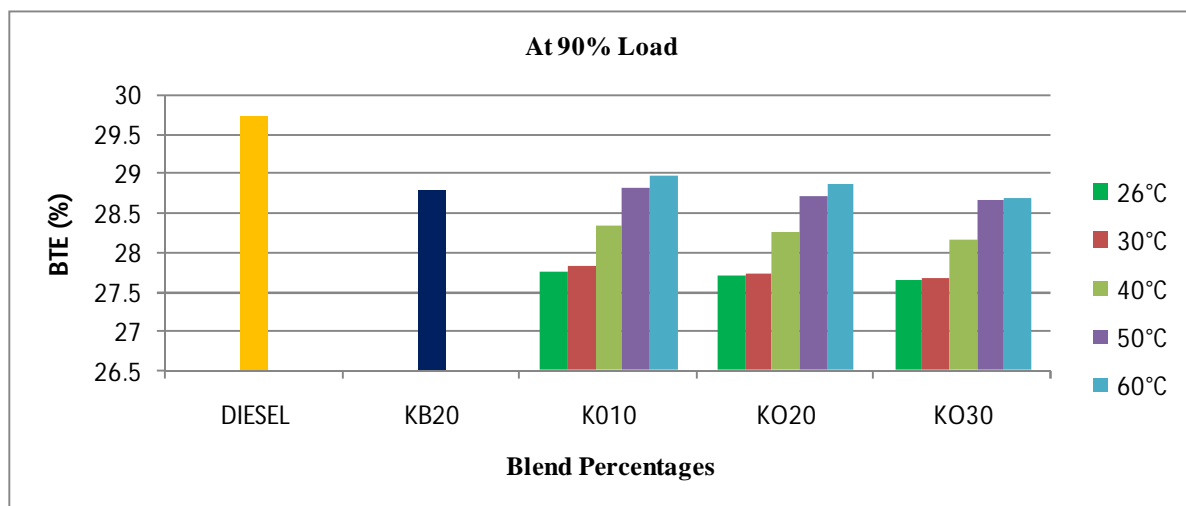


Figure 5: Variation of BTE against Preheated Karanja Oil Blends, KB20 and Diesel

Effect of temperature on density and viscosity of karanja SVO blends is very much significant at 60°C. At this temperature, density and viscosity of both KO10 and KO20 decreases to a large extent than that of KB20 and diesel. BTE of KO10 is more than KB20 and less than diesel for the same reasons as explained for 50°C. At this temperature, decrease in density and viscosity of KO20 is predominant over the higher calorific value of KB20. So, BTE of KO20 is marginally more than KB20. BTE of KO20 is less than diesel as the very high calorific value of diesel is predominant over the decrease in density and viscosity of KO20. BTE of KO30 is marginally less than all the considered fuel blends at this temperature also for the same reasons as explained for 50°C.

## 5.1.2 BRAKE SPECIFIC ENERGY CONSUMPTION (BSEC)

At 90% loading condition, Comparative results of BSEC for karanja oil blends at 26°C, 30°C, 40°C, 50°C, 60°C with KB20 and 100% diesel fuel at 26°C are analysed and represented graphically in Figure 6.

There is only marginal decrease in density and viscosity of Karanja SVO blends up to 40°C. Hence, higher oxygen content and higher calorific value of KB20 is respectively predominant over this decrease in density and viscosity resulting in lower BSEC compared to Karanja SVO blends. BSEC decreases with increase in load up to about 90% loading and then increases up to 100% loading. This is due to reduction in heat loss and increase in power with increase in load.

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 8, August 2017

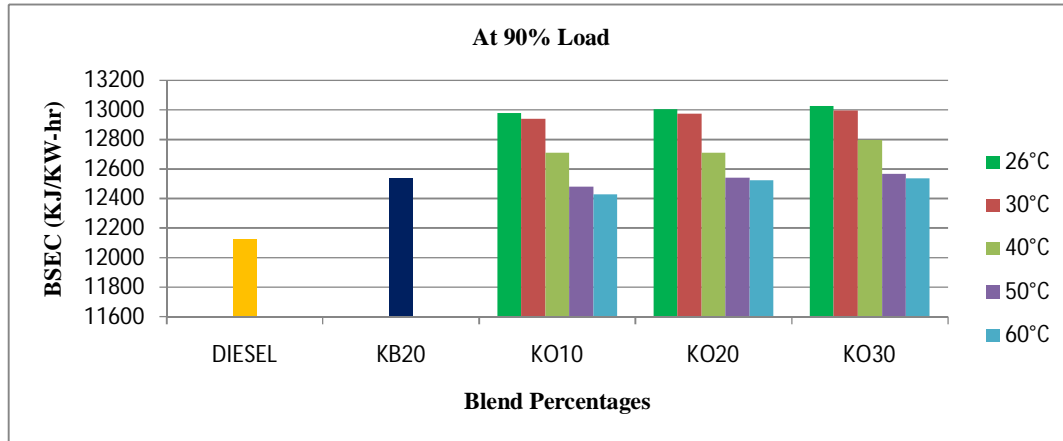


Figure 6: Variation of BSEC against Preheated Karanja Oil Blends, KB20 and Diesel

At 50<sup>0</sup>C, Density and viscosity of only KO10 becomes lower than KB20 and diesel which in turn improves the fuel spray characteristics and fuel droplets get atomized properly. As a result, better combustion takes place. Moreover, calorific value of KO10 is higher than KB20 which decreases the mass flow rates of KO10 and ultimately results in marginal decrease of BSEC of KO10 over KB20. But in case of diesel, it's very high calorific value is predominant over the decrease in density and viscosity of KO10. At this temperature higher calorific value and lower ignition delay of KB20 is predominant over marginal decrease of density and viscosity of KO20.

At 60<sup>0</sup>C, density and viscosity of both KO10 and KO20 decreases to a large extent than that of KB20 and diesel. BSEC of KO10 is less than KB20 and more than diesel for the same reasons as explained for 50<sup>0</sup>C. At this temperature, decrease in density and viscosity of KO20 is predominant over the higher calorific value of KB20. Moreover, lower ignition delay of KB20 may result in early start of combustion thereby increasing the compression work and loss of power. So, BSEC of KO20 is marginally less than KB20. BSEC of KO20 is more than diesel as the higher calorific value of diesel is predominant over the decrease in density and viscosity of KO20. BSEC of KO30 is marginally more than all the considered fuel blends at this temperature also because of its high density, high viscosity and low calorific value.

### 5.1.3 EXHAUST GAS TEMPERATURE (EGT) VERSUS LOAD

From the Figure 7 it is observed that at 90% loading condition, magnitude of EGT is exactly the reverse order of the magnitude of the brake thermal efficiency. The higher EGT indicates the poor energy utilization by the engine, which in turn represents lower BTE.

Density and viscosity of KO10 at 50<sup>0</sup>C is lower than KB20 which is well enough for better combustion generating a higher peak temperature in the early part of combustion phase. Because of higher ignition delay of KO10 than KB20, higher combustion temperature retains for a shorter term in KO10 compared to KB20. As a result of which EGT decreases in KO10. But for KO20 at this temperature, marginal decrease in density and viscosity is dominated by the better combustion of KB20. Because of which EGT of KO20 is more than KB20. Among all the considered fuels, diesel has the optimum density, viscosity and ignition delay period which facilitates better combustion decreasing the level of EGT.



# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 8, August 2017

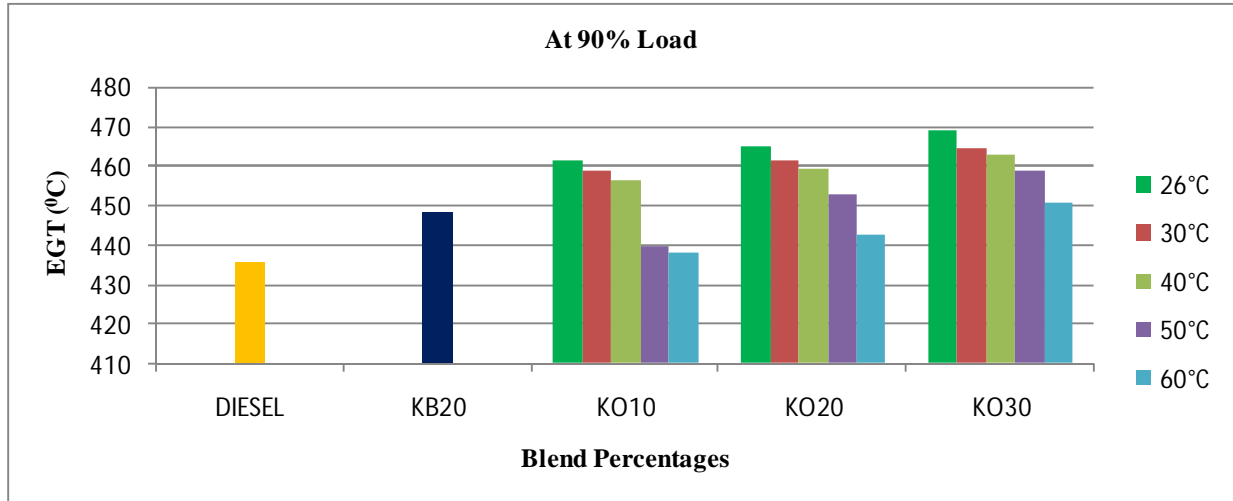


Figure 7: Variation of EGT against KO blends, KB20 and Diesel

Decrease in density and viscosity of KO10 and KO20 at 60°C, improves combustion generating peak temperature in the early part of combustion phase. KB20 has very much lower ignition delay than both KO10 and KO20. Because of which significantly longer residence time of higher cylinder temperature exists, this causes more EGT in case of KB20 than that of KO10 and KO20. Density and viscosity of KO30 is slightly more than diesel and KB20 at this temperature also. So, EGT of KO30 is more than all the considered fuels.

## 5.2 EMISSION RESULTS

### 5.2.1 NO<sub>x</sub> EMISSION VERSUS LOAD

At 90% loading condition, Comparative results of NO<sub>x</sub> emission from karanja oil blends at 26°C, 30°C, 40°C,

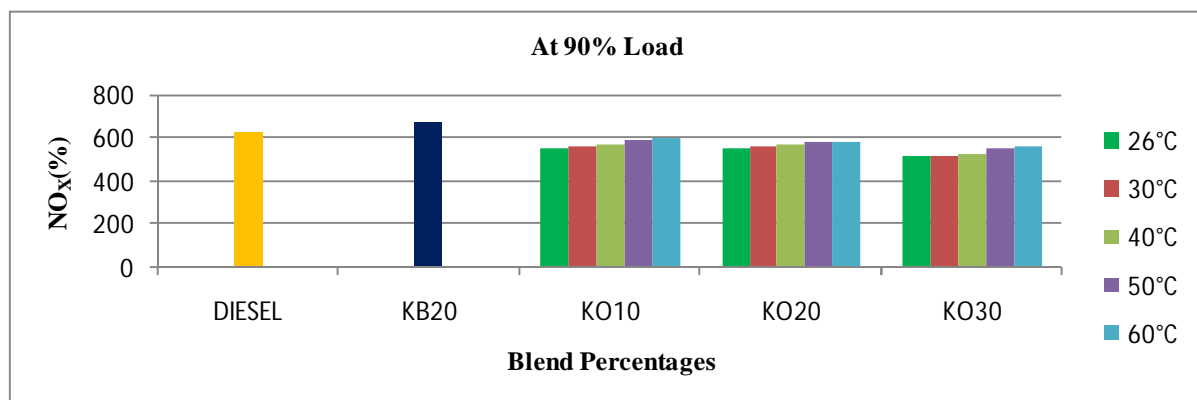


Figure 8: Variation of NO<sub>x</sub> Emission against KO blends, KB20 and Diesel

50°C, 60°C with KB20 and 100% diesel fuel at 26°C are analyzed and represented graphically in Figure 8. The formation of NO<sub>x</sub> is favored by higher combustion temperatures and availability of oxygen. It is observed that the NO<sub>x</sub> emissions decrease with increase in blend ratio for karanja oil which is attributed to lower average temperature generated because of incomplete combustion due to increase in fuel density and viscosity. NO<sub>x</sub> emission increases with increase in load because of increase in combustion chamber temperature with loading.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 8, August 2017

Unlike diesel, biodiesel contains oxygen. This fuel-borne oxygen, together with higher combustion temperature, favors production of more NO<sub>x</sub> than diesel fuel combustion. Karanja oil blends without preheating exhibits a lower value of NO<sub>x</sub> compared to both KB20 and diesel. The reduction in NO<sub>x</sub> emission with unheated karanja oil blends may be believed due to the reduced premixed burning rate following the delay period. That is the lower air entrainment and fuel air mixing rates with the unheated blends of karanja oil may result in low peak temperature and NO<sub>x</sub> levels. The NO<sub>x</sub> emission with preheated karanja oil blends is higher than that of karanja oil blends without preheating but it is still lower than KB20 and diesel. The increase in NO<sub>x</sub> with preheated fuel may be due to the rapid burning with an increase in fuel inlet temperature.

## 5.2.2 CO EMISSION VERSUS LOAD

At 90% loading condition, Comparative results of CO emission from karanja oil blends at 26<sup>o</sup>C, 30<sup>o</sup>C, 40<sup>o</sup>C, 50<sup>o</sup>C, 60<sup>o</sup>C with KB20 and 100% diesel fuel at 26<sup>o</sup>C are analysed and represented graphically in Figure 9. The effect of fuel viscosity on fuel spray quality would be expected to produce higher CO emissions with increasing SVO percentage in the blend. KB20 has the lowest CO emission compared to both the unheated and preheated karanja oil blends and diesel. This is possibly because biodiesels contain about 10% oxygen by weight. There will be extra oxygen to react with the fuel during the combustion process facilitating better combustion. Further, biodiesel has a lower carbon to hydrogen ratio. Thus, with less carbon in the fuel, there is a better chance that each carbon atom will find two oxygen atoms to bind to. All the unheated blends of karanja oil produce more CO emission as compared to diesel. The higher CO may be due to the poor spray characteristics as a result of higher viscosity of unheated blends because of which some of the fuel droplets will not get burned. When these droplets mix with the hot gases in the later part of the power

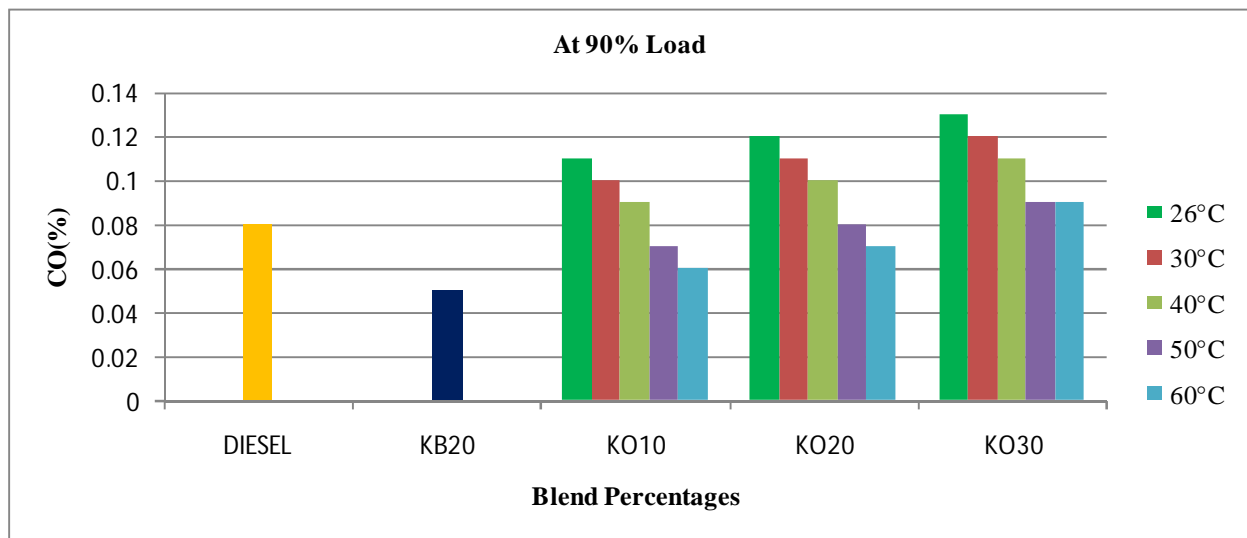


Figure 9: Variation of CO Emission against KO blends, KB20 and Diesel

stroke and early exhaust stroke, oxidation reaction of the fuel occurs but do not have enough time to undergo complete combustion. The increase in fuel temperature of preheated karanja oil blends will result in finer spray and thus good oxidation occurs. This is the reason for reduced CO with high fuel temperature. After attaining a temperature of 50<sup>o</sup>C, CO emission of KO10 becomes lower than diesel and at 60<sup>o</sup>C, CO emission of both KO10 and KO20 becomes lower than diesel. However, none of the preheated karanja SVO blends shows lower CO emission than KB20. Moreover, CO emission of all the considered fuel increases with increase in load. This is due to less oxygen available to oxidize the large amount of fuel present in higher loading conditions.

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

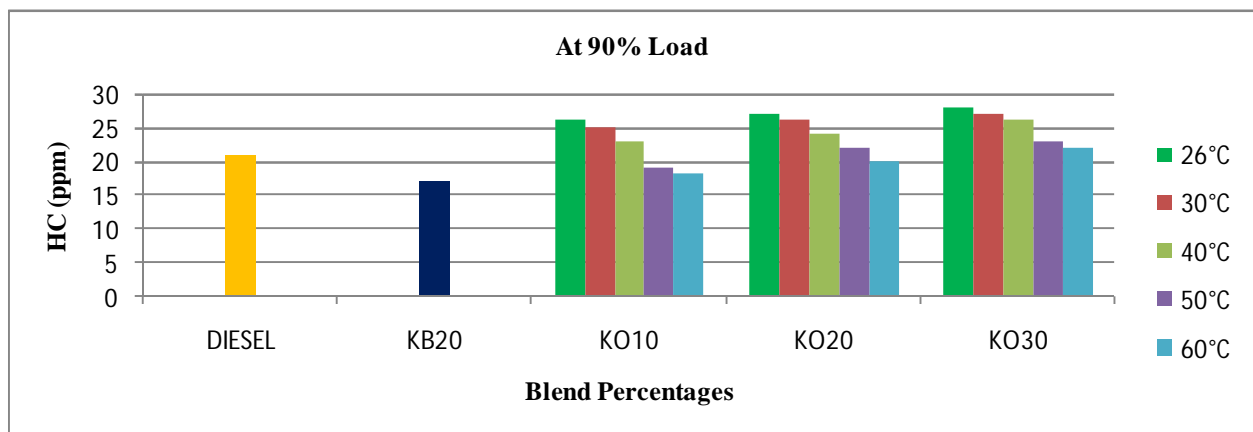
Vol. 6, Issue 8, August 2017

### 5.2.3. HC EMISSION VERSUS LOAD

At 90% loading condition, Comparative results of HC emission from karanja oil blends at 26<sup>o</sup>C, 30<sup>o</sup>C, 40<sup>o</sup>C, 50<sup>o</sup>C, 60<sup>o</sup>C with KB20 and 100% diesel fuel at 26<sup>o</sup>C are analyzed and represented graphically in Figure 10.

Higher density and viscosity of SVO causes poor mixture formation which results in partially burned hydrocarbons during combustion process. Hence the hydrocarbon emissions are higher for unheated karanja oil blends and it increase with increase in blend percentages. The HC emissions for Karanja oil blends decrease with increase in fuel inlet temperature. The reduction in HC emission at higher fuel temperature is due to better vaporization, as a result of improved atomization. HC emissions of all the considered fuel samples follow the same trend as that of CO emissions.

HC emission for KO10 at 50<sup>o</sup>C is less than diesel and for both KO20 and KO30 it is more than diesel. However, all the karanja SVO blends show higher HC emission compared to KB20. At 60<sup>o</sup>C, HC emission of both KO10 and KO20 is less than diesel. However, KO30 shows higher HC emission compared to diesel. At this temperature also, karanja SVO blends show higher HC emission compared to KB20. The reason for this trend of HC emission is same as explained that for CO emission.



**Figure 10:** Variation of HC Emission against KO blends, KB20 and Diesel

## VI. CONCLUSION

The engine performance tests along with the corresponding emission measurements against engine loading (0-100%) have been done on the experimental set-up for various blends of (both unheated and preheated) karanja SVO with diesel, KB20 with diesel and also for mineral diesel (stand alone). For all the considered test fuels of preheated karanja oil blends (KO10, KO20, KO30) and 20% karanja biodiesel blend (KB20) the engine performed best at 90% loading condition. The same results are true for diesel fuel also. Hence, the engine may be operated preferably at 90% loading condition for its best performance. The most suitable preheating temperature is found to be 60<sup>o</sup>C without any modification in the diesel engine system. However, one may go for more preheating of SVO blends than 60<sup>o</sup>C for obtaining better engine performance and lower emissions. But in that case at least some system modifications in terms of piping's, gaskets, seals, etc. are required, if not any major engine modifications. Considering mineral diesel, KB20 blend, and all KO blends (with and without preheating), the KO10 blend preheated up to 60<sup>o</sup>C is found to have superior performance and lower overall emissions followed by KO20 blend at the same preheated temperature, if one has to go for biofuel option in a CI engine. KO20 at 60<sup>o</sup>C performs better than KB20 and emissions are almost similar to KB20 in addition to 10% more saving of diesel when compared with KO10. Although KO20 is slightly inferior to KO10, considering the fact of more diesels saving in KO20, KO20 at 60<sup>o</sup>C may be considered to be the most suitable fuel blend which is evolved as a better choice than KB20. Moreover, with this preheated blend of fuel there will be no

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 8, August 2017

requirement of engine modification as this preheating can be achieved by using the exhaust gas of the same engine through a suitably designed heat exchanger assembly. The above findings can be very effective especially for cold climatic conditions.

The present work may be extended further in the following directions, which have been considered as future scopes of present work:

1. Comparison among varieties of potential SVOs and biodiesels may be considered to give a strong conclusion about the effectiveness of preheating over transesterification process.
2. Maximum temperature of preheating can be raised in order to see the effect of rise in temperature on performance and emission characteristics of higher blends of SVO.
3. Further study is required to optimize the preheating temperature for engines requiring no major and minor modifications.
4. The effective design of the heat exchanger assembly is considered as a future scope for this present work.
5. The present work has been focused on stationary engines. Similar study may be performed for moving engines to study the dynamic effects.
6. Energy analysis may be considered for finding out suitable blends by analyzing the experimental results.

## REFERENCES

- [1] Mirunalini T., Anand R., and Mahalakshmi N.V., "Jatropha oil as a renewable fuel in a DI diesel engine", Proceedings of the 3rd BSME-ASME International Conference on Thermal Engineering, Vol.1, pp.20-22, 2006.
- [2] Agarwal D., and Agarwal A.K., "Performance and emissions characteristics of Jatropha oil (Preheated and blends) in a direct injection compression ignition engine", Applied Thermal Engineering, Vol. 27, pp.2314-2323, 2007.
- [3] Pryor, R. W., Hanna M.A., Schinstock J.L., and Bashford L.L., "Soybean oil fuel in a small diesel engine", Transactions of the ASAE, Vol.26, pp.333-337, 1983.
- [4] Pryde, E. H., "Vegetable oil fuel standards, Vegetable Oil Fuels", Proceedings of the International Conference on Plant and Vegetable Oils Fuels. St. Joseph, ASAE, pp.81-3579, 1982.
- [5] Bajpai S., Sahoo P.K., and Das L.M., "Feasibility of blending karanja vegetable oil in petro-diesel and utilization in a direct injection diesel engine", Fuel, Vol.88, pp.705-711, 2009.
- [6] Chauhan B.S., Kumar N., Jun Y.D., and Lee K. B., "Performance and emission study of preheated Jatropha oil on medium capacity diesel engine", Energy, 35, 2484-2492, 2010.
- [7] Kadu S. P., and Sarda R. H., "Experimental Investigations on the Use of Preheated Neat Karanja Oil as Fuel in a Compression Ignition Engine", World Academy of Science, Engineering and Technology, Vol.48, pp.540-544, 2010.
- [8] Yadav H.J., Rathod P.P., and Sorathiya A.S., "Biodiesel preparation from karanja oil –an overview", International Journal of Advanced Engineering Research and Studies, Vol.1, pp.42-46, 2012.
- [9] Bari S, Lim T.H, and Yu C.W, "Effects of preheating of crude palm oil (CPO) on injection system, performance and emission of a diesel engine", Renewable Energy, Vol.27, pp.339-351, 2002.