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Testing of Four Stroke Diesel Engine on Karabi oil

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Abstract

As we know the resources of crude oil are depleting very fast and the concern for pollution is also very high, to address these concerns we need to have a fuel which could be developed from the renewable sources and also the efficiency of the engine get increased for the above mentioned problem we have proposed fuel combination based on fossil crude oil and the oil extracted from the karabi seeds which will not only reduces the pollution caused by fossil fuels but also reduces the whole sole dependency of engines running on fossil fuels. In this research an effort is made for the generation of bio-fuel by a natural resource. For this Karabi oil is produced from Karabi flower by various chemical processes and filtration methods after which it can be used as bio-fuel and testing have been done on four stroke diesel engine to check the performance of this fuel including emissions from engine which are eco friendly and more economical than current petro diesel. For this the injection and atomization characteristics of karabi oil will be modified and viscosity of oil will be made so that it can be easily applicable as bio-fuel. The conversion of Karabi oils into biodiesel is an effective way to overcome all the problems associated with the vegetable oils. Dilution, micro emulsification, and trans-esterification are the four techniques applied to solve the problems encountered with the high fuel viscosity.

Keywords: Four stroke Diesel Engine, Bio-Fuel, Bio-diesel, Karabi oil, pollution reduction.

1. Introduction

Fuels are any materials which have stored potential energy in form which can be released and used as heat energy by application of chemical or mechanical processes. The concept is applicable for materials which stores energy in chemical form which is being released out through application of various process of combustion ,but the application of concepts is also same for different sources of heat energy, and also for those which are releasing chemical energy through non-combustion oxidation .The heat energy which all the fuels releases can be transformed to mechanical form of energy by a mechanical device called engine and often the heat by itself is also utilized for heating, for making food, or for providing required energy in industrial processes. Fuel is also utilized by the cells of organisms or living creatures which is processed by various chemical process inside the body of creatures and the process is known as cellular respiration, where organic molecules are getting oxidized by some chemical reactions to release usable energy. Hydrocarbons “the most utilized sources of fuel” which is used by vertebrates and other substances which are used as source of energy (Fuels) are radioactive metals. Fuels often are also varies as its methods of storing potential energy are different, such as those which are directly releasing electrical energy or mechanical energy.

2. Literature Review

Hossain and Boyace (2009) : This Paper researchers used waste sunflower oil for testing and described the benefits of utilizing sunflower oil as environmental recycling process and renewable energy and give Comparison of the basic required conditions of alkaline-catalyzed trans-esterification process for biodiesel production from purest form of sunflower oil and residual sunflower oil also which is used for cooking for the sake to get extreme quality biodiesel that will be capable of fulfilling all the specification and methods which are set as standards like(ASTM D 6751 & EN 14214).The most about 99.5% bio-fuel yield was analyzed under desired conditions of approximately 1:6 volumetric ratio of oil-to-methanol, 1% potassium hydroxide catalyst at near about 35-40ºC reaction temperature and 320-350 rpm stirring speed. From results it is seen that the biodiesel produced from purest form of sunflower oil and waste cooking sunflower oil had no considerable differences. The researchers analyzed that the bio-fuel which was obtained by following all standard specifications from sunflower oil.

Hossain et al. (2010) : Again these researchers found some new area of investigation and their research was been done on biodiesel which is basically derived from microalgae i.e. cell factories which are driven by sunlight for the conversion of co_2 to bio-fuels as methane is extracted by a process of anaerobic digestion of algae biomass and photo-biologically produced bio-hydrogen. The most important factor using micro-algae was that it doubles its mass within 24 hours so that production rate can be high enough and contains 80% oil by weight of dry bio-mass so the productivity desired for producing bio-diesel can be achieved. Researches has showed that fuel from micro-algae will be carbon neutral and the total biomass of micro-algae contains approximately half carbon by dry weight which all are extracted from carbon di oxide and all the power which is required for production and processing of algae will also come from bio-diesel by itself and from methane which is produced by anaerobic digestion of biomass. As show in researches fuel generated from micro-algae have all potential to completely displace the petro-diesel but still now economics for producing bio-fuel from microalgae needs some more improvement in processes to make it more effective and this can only be possible by utilizing the concept of bio-refinery and photo bioreactor which gives controlled structure that can lead to the high production rate of algae to attain good annual yield of oil. Renewable, carbon neutral, transport fuels are importantly necessary for eco-system and economical sustainability.

3. Proposed Approach:

This bio fuels research has focused entirely on the manufacturing of bio-fuel from karabi oil to use as a dominant alternative fuel for the use in diesel engines. The present research on karabi oil was taken to analyze the effect on the environment. In order to study the biodiesel effects of the 4-stroke engines, the present work would be production of bio-fuel from karabi oil and to analyze the computational observations of performance characteristics, engine emissions, effect on atmosphere and to determine the values of karabil oil and diesel such as densities, kinematic viscosity of fuel, its property of ignition and stability with oxygen(oxidation stability) by graphs between temperature readings at various different positions for the different inputs and by comparing standard data with data recorded in lab. The effect of ethanol for the studies of 4-stroke engine is compared for the different fuel.

Objective: To obtain a desired bio-fuel compositions that can be serve a good substitute of fuel to utilize in diesel engines without affecting the characteristics and performance on working of diesel engine.

4. Bio-Diesel

Bio fuels are energy carriers that have energy stored in it which is derivative of biomass, which is basically made from eighter plants, animals' wastes and micro-organisms and organic wastes. Bio fuels may be in the form of solids, liquid and gases including all types of bio source of energy and derived forms used for energy production. They are a possible replacement of fossil fuels. On comparing with the latter product, there are some benefits to use bio fuels. Advantages and benefits of bio fuels, however, depend on the category of the particular bio fuel, type of feedstock used and technology used for the production of it. The two most dominant replacements of petro and diesel fuels used for transportation are ethanol and biodiesel, respectively. Transport is one of the largest energy consuming sectors. It is considered that biodiesel can be successfully used as a replacement of petroleum diesel and ethanol can serve to be is used as a replacement of gasoline. Bio fuels for transportation are basically driven by policies which are defined by government; the production of ethanol for transportation purpose was tripled between the years 2000 to 2007 from 17 billion to more than 52billion liters, while biodiesel expanded eleven-fold from less than 1 billion to almost 11 billion liters. These fuels together provided 1.8% of the world's transport fuel by energy value. There is a large variety of bio fuels available which can be used potentially as substitute of petro-diesel, but the most dominant which are considered as good bio fuels globally are biodiesel and bio ethanol. Bio-ethanol is manufactured from a number of crops including sugarcane, corn, wheat grain and sugar beet. Biodiesel is a fuel that is manufactured directly from vegetable oils, edible and non-edible, waste vegetable oils, and animal's fat.

5. Process of extraction

Bio-diesel is basically obtained from Karabi oil by chemically altering their properties by the process known as "Trans-esterification". In this oil is heated to a temperature of about 55 ^{0}C, while stirring there is some addition of titrated mixture of Methanol and potassium dioxide added to it after that the mixture is allowed to cool at room temperature then fuel is separated with fatty acids at the down bottom.

5.1 Collection of Seeds

Fruits of Karabi tree (Nerium oleander Linn.) were collected from different *plant nursery*. Seeds of this plant were hard shell like structure and these shells are dried to remove outer shell from fully matured seeds for the sake to make it apart from its inside brown colored core containing four units of inner seeds and then these seeds were pressed by using screw press and oil (58.5%) was extracted from flower seed and further filtered by filter paper.

Figure 1. Karabi Seed

Figure 2. Karabi Seed

Figure 3. Bio-diesel produced in the Lab.

5.2 Pressing of Karabi seed

After waiting for 24 hours for the sake to minimize its moisture content and drying the seeds, 2 kilogram of karabi seeds were pressed which produced 500 ml of karabi oil and pressed oil then filtered by using filter paper for approximately one day and then 100 ml of the filtered oil was used for the determining the percentage of free fatty acid present in oil.

Figure 4. Karabi oil presses in lab

5.3 Determining percentage of free fatty acid in Karabi oil

20 grams of the purified Karabi oil was poured in a 250 ml Erlenmeyer flask and then 100 ml of ethanol and diethyl ether were added on it, and then oil was mixed completely with solvent mixture. Then a solution of about 10-15 ml of ethanolic potassium hydroxide with 3-4 drops of phenolphthalein (1% in ethanol) was imparted to the solution in the Erlenmeyer flask mixture

(mixture titration) and wait for the change in color of mixture, when the color of the mixture changed, the mixture was left for few second to be satisfaction of the new color.

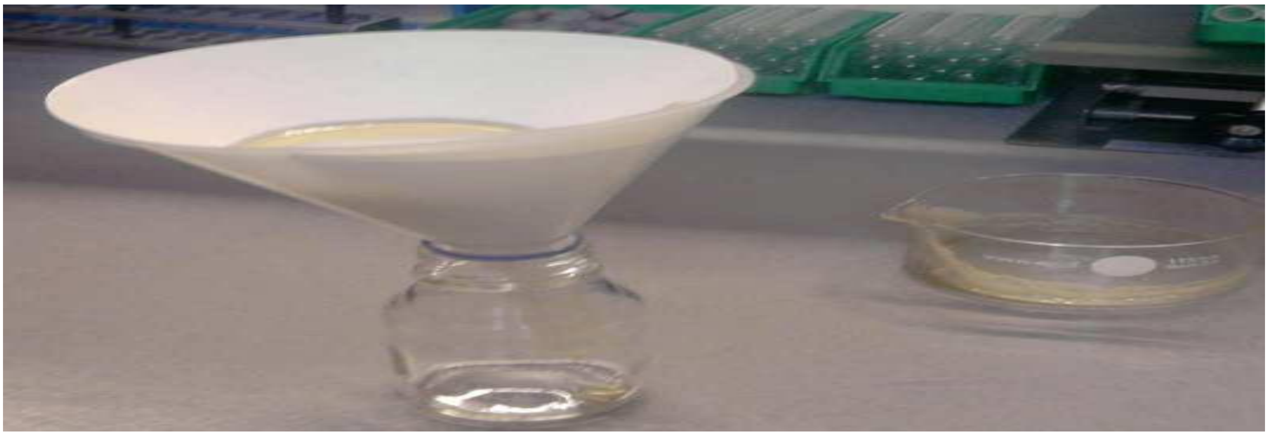

Figure 5. The Filtration of 50 ml of Karabi oil in lab

A formula to determine the free fatty acid concentration in Karabi oil:

% free fatty acid = a * avg. mol. wght. / 10 * E

Where,
a - volume [ml] of KOH * 0.1 [mol / ml]
E - Initial weight in grams
avg. mol. wght. -314 g / mol

5.4 Trans-esterification

KOH dissolved in methanol was allowed slowly to put drops wise in Karabi oil which is heated at 30 ^{o}C and kept in stir and now oil was left for the next one day.

5.5 Thin layer chromatography

This is used to check the impurities present in sample and how many different compounds are used to make a sample. In this a very small quantity of the sample is placed on the special TLC plate and then it is kept in a container containing solvent mixture where solvent runs over the plate and separates the different molecules based on their polarity and size differences. The two phases of thin layer chromatography which are used for different type of samples are a stationary phase for solid of liquid supported by a solid and a liquid or a gas mobile phase.

Figure 6. Thin layer chromatography devices in the Lab.

The mobile phase flows always through stationary phase which carries the mixture components with it and different phase components moves at different rates, in this case the stationary phase is silica gel which is coated on a thin piece of dense and rigid plastic and the mobile phase is a mixture of solvents hexane and ethyl acetate in a specific ratio (v/v).

6. Result and Discussion

Table 1. Experimental results of Oxidation stability for Karabi oil, and diesel fuel.

Fuel type	Oxidation stability(hours)
Karabi oil	3.03
Diesel	16.38

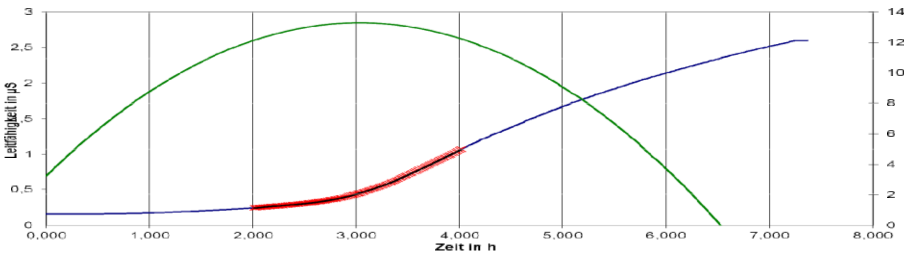

Figure 7. show the oxidation stability of Karabi oil. The red line shows the point at where the conductivity curve bends which is defined as the oxidation stability.

It could be noticed from table 1 that the oxidation stability for Karabi oil is 3.03 hours.

6.1 Engine used

4 cylinder 4 stroke diesel engine model EduTek-224H, it is a three cylinder swirl chamber engine with a total displacement of 1.1 liter. The engine is used for driving a generator for the production of electricity; waste heat of the engine is used for heating (co-generation unit).Electric and thermal power of co-generation unit respectively is 5 and 12 KW, respectively.

Figure 8. 4 cylinder 4 stroke diesel engine

Table 2. Engine specifications

Sr. No	Particulars	Specification
1	Model	224H
2	Make	Kirloskar EduTek
3	Power(kW)	27.6KW
4	Speed(rpm)	5000RPM
5	Cylinder Bore	88.9
6	Stroke Length	101.6
7	Connecting Rod	177.8
8	Cubic Capacity	2523 cc
9	Compression	18:01:01
10	No of Strokes	4
11	No of Cylinder	4
12	Cooling	Water Cooled
13	Fuel	Diesel

Figure 9. Smoke / soot samples in lab

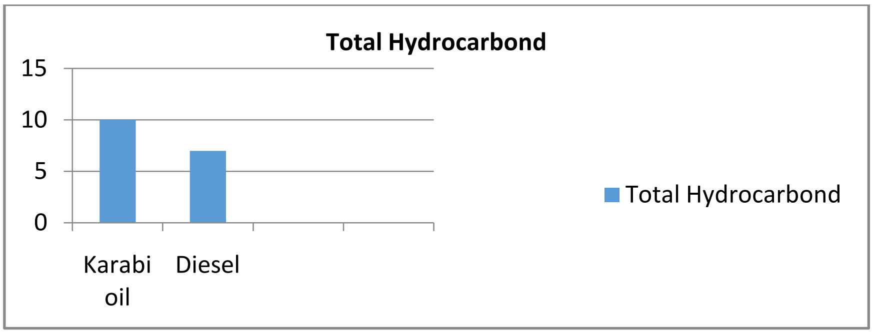

Figure 10. Resulted hydrocarbon emissions for Karabi oil and Diesel

Table 3. Characteristic properties for karabi 0il according to oil standards (DIN 51 605)

		Limiting Value	
Properties	**Unit**	**Min.**	**Max.**
Density (15ºC)	kg/m3	900	930
Kinematic Viscosity(40º)	mm2/S	-	38
Calorific Value	kJ/kg	35000	-
Oxidation Stability (110ºC)	H	5	-
		Limiting Value	
Properties	**Unit**	**Min.**	**Max.**
Density (15ºC)	kg/m3	900	930
Kinematic Viscosity(40º)	mm2/S	-	38
Calorific Value	kJ/kg	35000	-
Oxidation Stability (110ºC)	H	5	-

Table 4. Characteristic properties for karabi 0il according to experiments done in the Lab

Properties	**Unit**	**Value**
Density (15ºC) Hydrometer	kg/m3	921
Pycno meter		922
Kinematic Viscosity (40ºC)	mm2/s	36.22
Lower heating value	kJ/kg	36922
Oxidation Stability (113ºC)	H	3.03

Table 5. Characteristic properties for Diesel according to experiments done in the Lab.

Properties	Unit	Value
Density		
Viscosity at 40°C	mm²/s	3.095
Lower Heating	kJ/kg	46221
Oxidation stability		

Table 6. Three different readings for the total hydrocarbons in three different times and three different readings for ash number for every fuel.

Fuel type	Total hydrocarbons(ppm)@different times			Ash number (samples)		
Karabi oil	10	9	10	6.7	6.8	6.9
Diesel	7	6.5	6	5	5.3	6.5

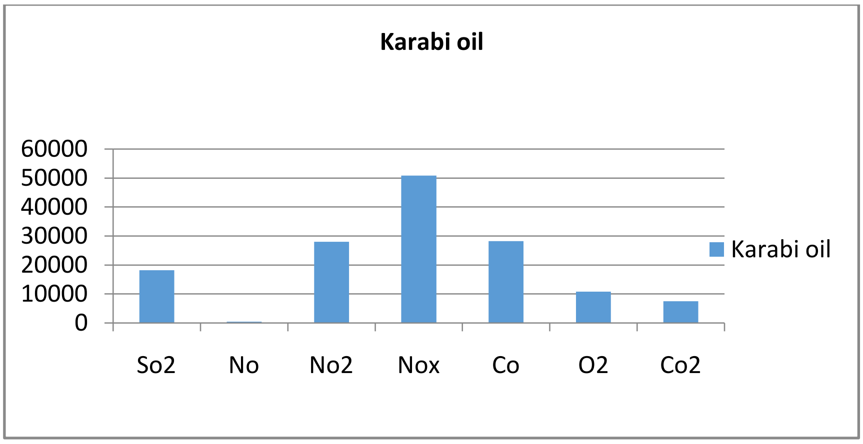

Figure 11. Resulted So_2, No, No_2, Nox, Co, O_2, Co_2 emissions for Karabi oil

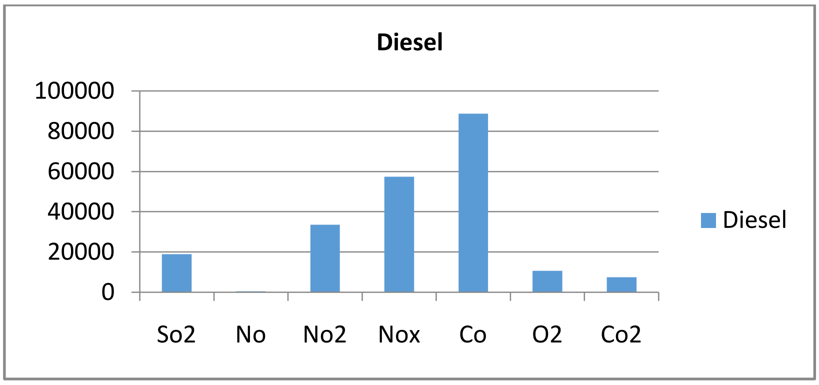

Figure 12. Resulted So_2, No, No_2, Nox, Co, O_2, Co_2 emissions for Diesel

6.1 Bio-Diesel Effects on Performance of Engine

The engine performance has been evaluated on the basis of desired perimeters which have been discussed above for comparing the test fuels. As we can see in figure 4.4 In case of B20 and B100 it is senn that BSFC of the engine increases. This result was expected due to more density and less heating value of bio-diesel than diesel.

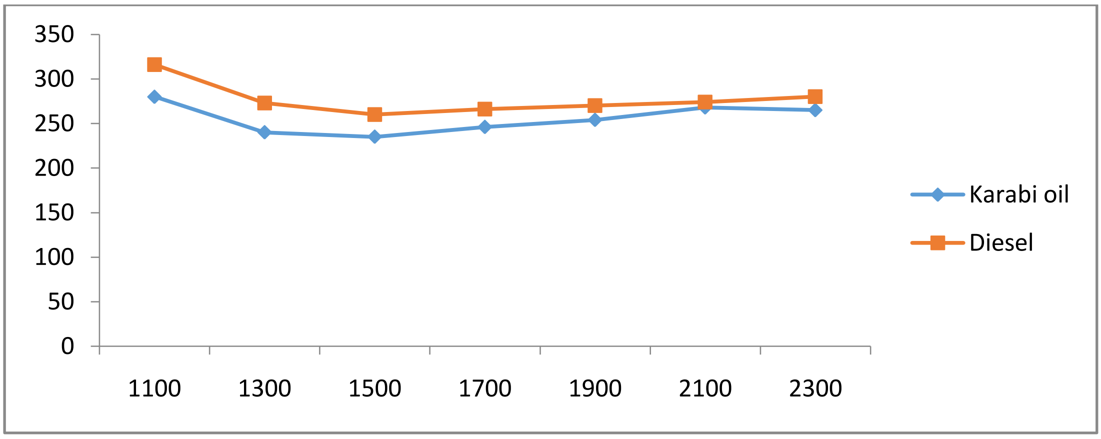

Figure 13. Effect of biodiesel on BSFC

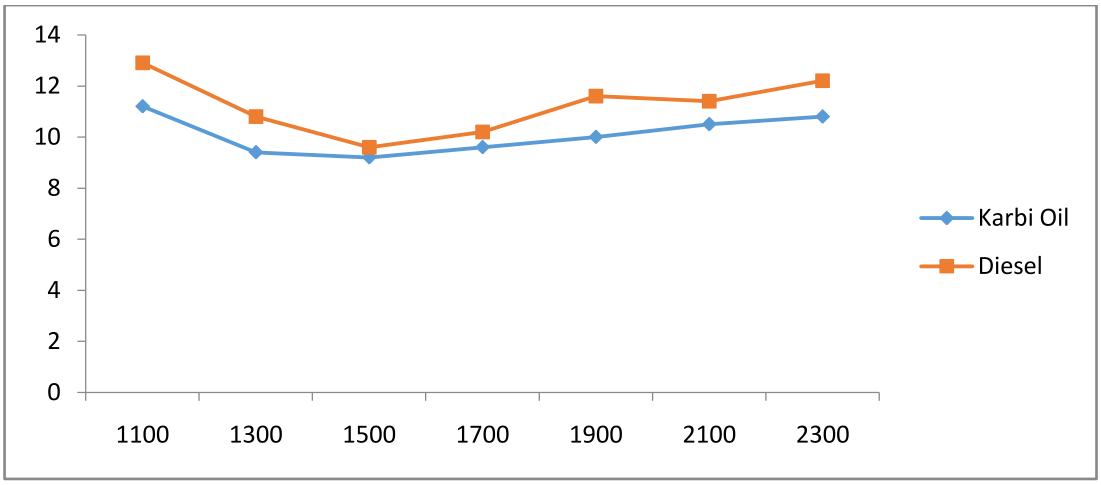

Figure 14. Effect of biodiesel on BSEC

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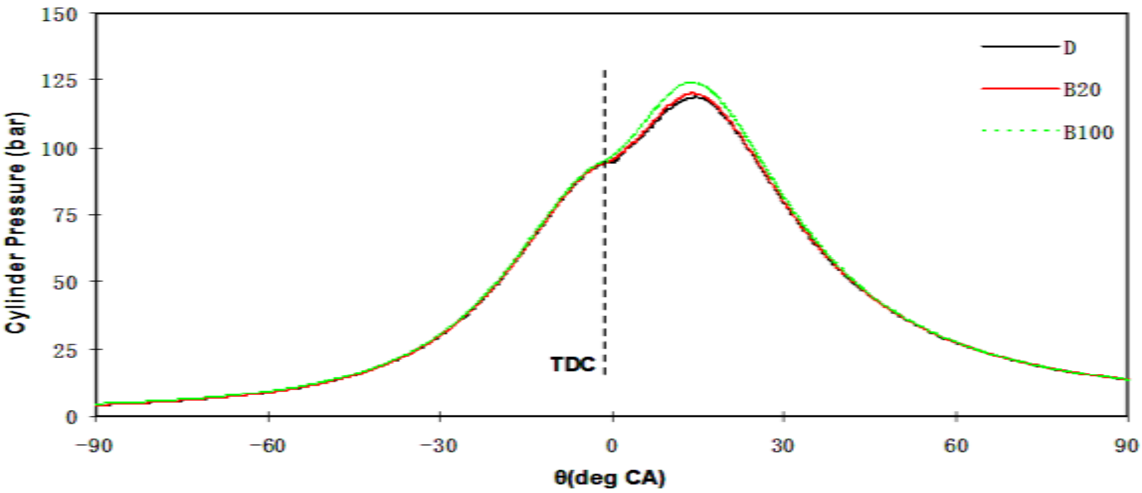

Figure 15. Cylinder pressure versus crank angle graphical representation at 1400 r/min.

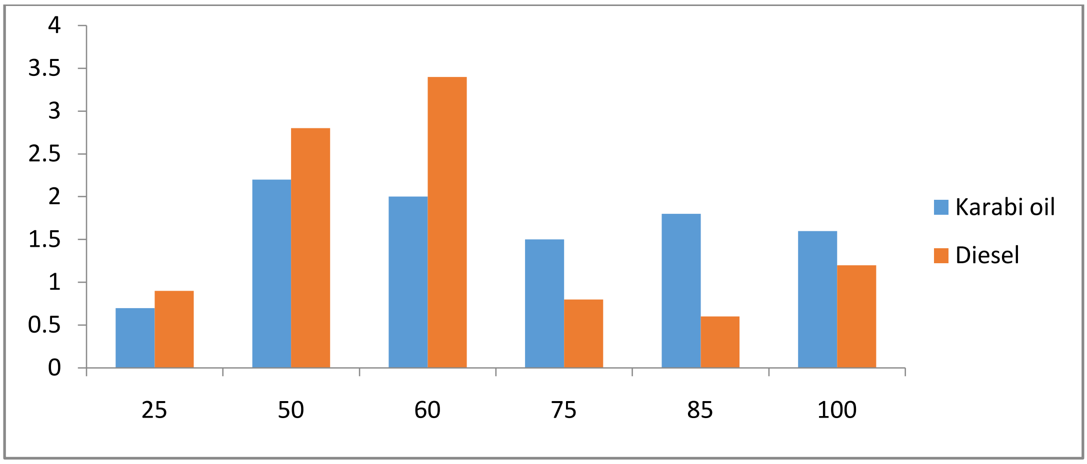

Figure 16. Effect on rate of pressure rise for varying speed with biodiesel

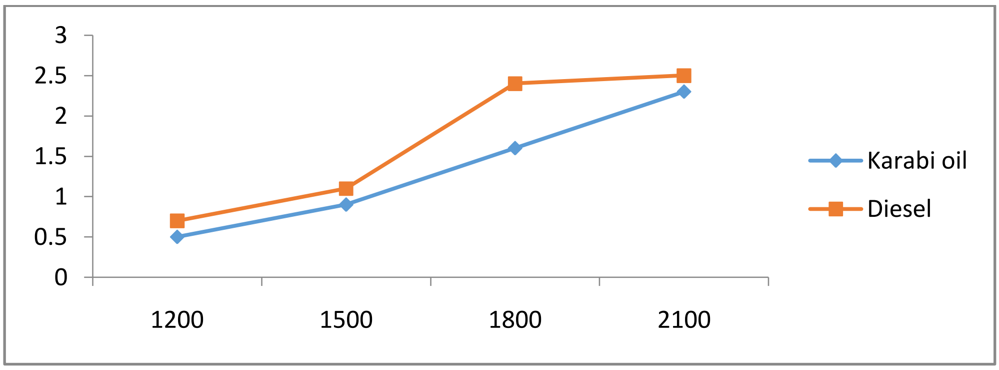

Figure 17. Effect on the premixed combustion zone for variable speed with bio-diesel

7. Results

It is cleared when comparing the results for emission testing of petro diesel and karabi fuels. For SO2, it is free from sulfur hence produces less sulfate emissions, but according to the experimental values of SO2 emissions which are given in table 6.4, it is clear that the SO2 emission of it is somehow less than petro diesel, actually diesel has the approximately equal value of SO2 when compared to Karabi fuel in figure 4.2. This can be little bit different result because the SO2 channel of the gas analyzer was not calibrated with it due to the lack of reference gas for SO2. Moreover, the diesel which was used for experimental purpose was a low-sulfur diesel, which proves that the results that were got can be different. For the NOx, which is combination of NO and NO2 emissions, diesel has higher nitrogen oxide NOx emissions than Karabi oil. Because of higher cetane rating and oxygen content in fuel, nitrogen present in atmosphere is oxidizes quickly. From experimental data of NOx emissions it is cleared that karabi oil has lower emission o nitrogen oxide than diesel. For CO emissions, CO emissions are reduced in the exhaust when using karabi oil used as fuel, because biodiesel contains more oxygen than diesel fuel and these results in complete combustion. It also has lower CO emissions than diesel, and this means that the combustion for it was appropriate, and hence produced less CO emissions than diesel fuel. For the CO2, it provides a means of recycling carbon dioxide, so there is no net increase in global warming. As with any complete combustion, CO_2 and H_2O are the end products, but these will be taken up by the plant to ultimately lead to production of new biodiesel. According to the experimental results, it is cleared that bio-fuel and diesel have very close values of CO2 emissions, but the bio-fuel is slightly higher, maybe this is because bio-fuel has to burn more hydrocarbons, to give the equal amount of energy that the diesel fuel does, because it has lower heating value than diesel, and because of that more CO2 is produced. For O2, the experimental results for diesel and biodiesel are close to each, biodiesel has slightly higher value, and this is because of the oxygenated nature of biodiesel. Hydrocarbon emissions are lower in case of bio-fuel than diesel. This is because of the oxygenated nature of bio-fuel resulting in reduction of hydrocarbon emissions in the exhaust, and use of biodiesel results in a substantial reduction of un-burned hydrocarbons, and according to the experimental results, that the hydrocarbon emissions of biodiesel is less than those for hydrocarbons by almost 30% which means the hydrocarbons emissions are reduced when using bio-fuel compared to diesel fuel.

8. Conclusion

In a world where petroleum reserves are becoming limited and will eventually run out and the critical issue of oil peak and the environmental concerns, all are getting involved in deeper research into the area of searching alternatives to fossil fuels which are bio fuels such as biodiesel and bio ethanol. As from the results it is clear that use of bio-fuels produced from various natural resources can be a efficient replacement of current fossil fuels due it their easy of availability and bio-degradable nature so that it is also less harmful for our environment than fossil fuels. Biodiesel is a good replacement for diesel fuels in diesel engines. It burns like petro-diesel but somehow gives low power and it is environment friendly. So it can be necessarily implemented the utilization of bio-diesel over current petroleum and gasoline because of all the merit which brings it forth to the table for use it as commercial purpose. In comparison to petroleum and gasoline, biodiesel beats diesel in all categories like emission of toxic substance and possesses no threat to the environment. The overall excretion and utilization of biodiesel consumes more carbon dioxide than it emits, thus making it a valuable in preventing global warming. By using biodiesel in the place of petroleum diesel, not only will we be helping the environment with a much better alternative, but we would be significantly reducing many health risks. The fact that most bio-fuels are domestically produced and market of biodiesel would actually stimulate the economy, reducing the dependency of country on foreign oil imports. Also, the implementation of biodiesel is extremely easy and requires little or no modifications to the typical diesel engine, for easy and smooth transition. It is clear that it brings more than it takes away because bio fuels are easily available from common biomass sources, carbon dioxide cycle occurs in combustion, they are very environmentally friendly, and they are biodegradable and contribute to sustainability .

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Nomenclature

AFV	Alternative Fuel Vehicles
ASTM	American Society of Testing &
BOCLE	Ball on Cylinder Lubricity Evaluator
CAA	Clean Air Act
CFPP	Cold Flow Plug Point

CMSA	Consolidated Metropolitan Statistical
CO	Carbon Monoxide
CO2	Carbon Dioxide
DI	Direct Injection
DOE	U.S. Department of Energy
EMA	Engine Manufacturers Association
EPAct	Energy Policy Act
FAME	Fatty Acid Methyl Ester
FAPRI	Food and Agricultural Policy Research
FTP	Federal Test Procedure
GHG	Greenhouse Gas
HC	Hydrocarbons
HFRR	High-Frequency Reciprocating Rig
LDV	Light-Duty Vehicles
MCA	Montana Code Annotated
MECA	Manufacturers of Emission Controls
MoDOT	Missouri Department of Transportation
MSA	Metropolitan Statistical Area
NAAQS	National Ambient Air Quality
NCOC	National Carbon Offset Coalition
NOx	Nitrogen Oxides
OEM	Original Equipment Manufacturers
PAH	Polycyclic Aromatic Hydrocarbons
PM	Particulate Matter
ppm	Parts per million
SIP	State Implementation Plan
SO2	Sulfur Dioxide
VOC	Volatile Organic Compounds