Emission Analysis of C.I. Engine using Karanja oil and its blends

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Abstract -*This study investigates the feasibility of biodiesel as a petroleum diesel substitute. This paper presents the results of tests carried out on diesel engine run on biodiesel produced by transesterification of Karanja oil and its blends with petroleum diesel. Engine tests have been carried out with the aim of comparing emissions parameters such as CO, CO_2, NOx, etc. For biodiesel mixtures CO emissions is lower than that of diesel fuel. As the amount of biodiesel in the blend increases, the amount of CO emission decreases. This variance is in the range of 8-10%. Blends up to B60 do not show any significant increase in the amount of CO_2 i.e. only about 2% increase than that of diesel is observed. However, for B80 and B100 blends, 7% and 11% increase is observed respectively. This rise is observed due to more efficient combustion of fuel. The variation of NO_x emissions for various blends with respect to load .The emissions increase for biodiesel than that of diesel. This increase is linear with the increase in biodiesel content in blend. Increase is 52-54% for B20 and B40, 60% for B60, 72% for B80 and 85% for B100. Considerable reduction in exhaust emissions, make blends of Karanja esterified oil a suitable alternative fuel for diesel engines without any engine modification and could help in facing the upcoming energy crisis and controlling air pollution.*

Keywords- *C.I.Engine, Biodiesel, Karajan, Fuel Efficiency Meter, Emission Analysis*

I. INTRODUCTION

Biodiesel is the name of a clean burning alternative fuel, produced from domestic, renewable resources. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend. Biodiesel is simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics.According to the American Society for Testing and Materials (ASTM) Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels, biodiesel is defined as a mono alkyl esters of long chain fatty acids derived from vegetable oils or animal fats, for use in compression-ignition diesel engines.

Biodiesel is made through a chemical process called transesterification whereby the glycerin is separated from the fat or vegetable oil. The process leaves behind two products methyl esters (the chemical name for biodiesel) and glycerin. The transesterification is achieved with monohydric alcohols like methanol and ethanol in the presence of an alkali catalyst.
Biodiesel fuel can be prepared from oils extracted from oil seeds, such as jatropha, castor, karanja, palm, soybean, canola, rice bran, sunflower, coconut, corn oil or fish oil, chicken, algal oil or waste cooking oil. Biodiesel and its blends with petroleum-based diesel fuel can be used in diesel engines without any significant modifications to the engines. The advantages of biodiesel are that it is renewable, biodegradable, more oxygenated, non toxic and essentially free of sulphur and aromatics and lower CO_2 emissions over the life cycle of the fuel.

Murari Mohon Roy [1] suggests that the average fuel consumption with B20 and B100 is higher than diesel. At low speed low load and high speed full load operations, the fuel consumption with biodiesel is much higher than diesel as compared to other conditions. In moderate engine speed and load conditions, the thermal efficiency of biodiesel and blends is as good as diesel.D. Ramesh and A. Sampathrajan [2] propose that the fuel properties of jatropha biodiesel were found to be similar to the diesel fuel. In the case of jatropha biodiesel alone, the fuel consumption was about 14 per cent higher than that of diesel. The per cent increase in specific fuel consumption ranged from 3 to 14 for B20 to B100 fuels. The brake thermal efficiency for biodiesel and its blends was found to be slightly higher than that of diesel fuel at tested load conditions and there was no difference between the biodiesel and its blended fuel efficiencies. For jatropha biodiesel and its blended fuels, the exhaust gas temperature increased with increase in load and amount of biodiesel. The carbon monoxide reduction by biodiesel was 16, 14 and 14 per cent respectively at 2, 2.5 and 3.5 kW load conditions. The NOx emission from biodiesel was increased by 15, 18 and 19 per cent higher than that of the diesel fuel at 2, 2.5 and 3.5 kW load conditions respectively.R. K. Singh and Saswat Rath [3] put forward that Karanja methyl ester seems to have a potential to use as alternative fuel in diesel engines. Blending with diesel decreases the viscosity considerably. The brake thermal efficiency of the engine with karanja methyl ester-diesel blend was marginally better than with neat diesel fuel. Brake specific energy consumption is lower for karanja methyl ester-diesel blends than diesel at all loading. The exhaust gas temperature increases with concentration of karanja methyl ester in the fuel blend due to coarse fuel spray formation and delayed combustion. The mechanical efficiency achieved with KME30 is higher than diesel at lower loading conditions. N. Stalin and H. J. Prabhu [4] found that for all the fuel samples tested, torque, brake power and brake thermal efficiency reach maximum values at 70% load. The dual fuel combination of B40 can be recommended for use in the diesel engines without making any engine modifications. Md. Nurun Nabi et al.

II. EXPERIMENTAL SET-UP

Experiments were carried out on a four stroke, naturally aspirated single cylinder, direct injection diesel engine. The engine has 661 cc cylinder volume and compression ratio of 17.5:1. The experimental set-up consists of a diesel engine, an engine test bed, fuel consumption metering equipment, gas analyzers, eddy current dynamometer, rotameter, etc. The detailed specifications are given in Table I. Emissions are measured using fuel efficiency meter manufactured by Technovation Analytical Instruments Pvt. Ltd., Mumbai. The electrochemical sensor used in the instrument converts the concentration of the gas encountered around it into an electrical signal, which is sensed by the instrument and displayed in terms of percentage or ppm.

Fig. 1.Experimental Set-up of C.I.Engine

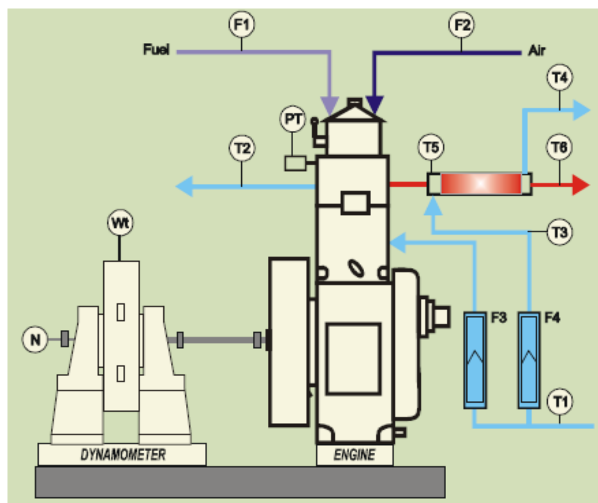

Fig. 2. Schematic Representation of C.I.Engine

TABLE I
ENGINE SET-UP SPECIFICATIONS

Particulars	**Specifications**
Engine	Kirloskar manufactured, 1 cylinder, 4 stroke Diesel, water cooled, power 3.5 kW at 1500 rpm, stroke 110 mm, bore 87.5 mm. 661 cc, CR 17.5, Modified to VCR engine CR range 12 to 18
Dynamometer	Type eddy current, water cooled, with loading unit

Propeller Shafts	With universal joints
Fuel Tank	Capacity 15 lit with glass fuel metering column
Calorimeter	Mono-block Pump
Pump	Pipe in pipe
Crank angle sensor	Resolution 1°,5500 RPM, TDC pulse
Temperature sensor	RTD (PT100), Thermocouple (Type K)
Load indicator,Load Sensor	Digital, 0-50 Kg, Supply 230VAC, Load cell, type strain gauge, range 0-50 Kg
Rotameter	Engine cooling 40-400 LPH; Calorimeter 25-250 LPH
Overall dimensions	W 2000 x D 2500 x H 1500 mm

III. FUEL EFFICIENCY METER

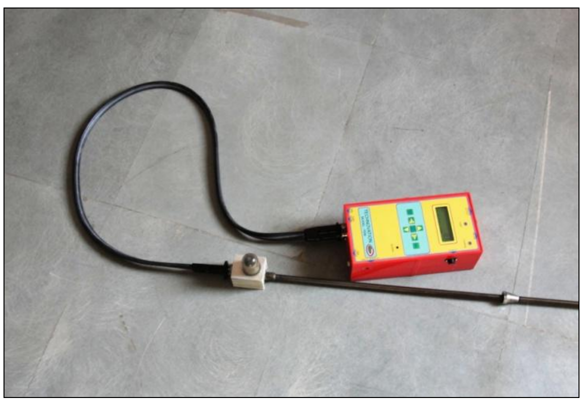

Fig.3. Fuel Efficiency Meter

The heart of instrument is the electrical sensor, which converts the concentration of gas encountered around it into an electrical signal, which is sensed by instrument, amplified, compensated, and displayed in terms of percentage and/or PPM on the LCD. There is one sensor per gas measured. Temperature is measured by a thermocouple

TABLE II
FUEL EFFICIENCY METER METERING RANGE

Gas	**Range**	**Resolution**
Oxygen	0-25%	0.1%
Carbon monoxide	0-2%	0.001%
Sulphur dioxide	0-2000 ppm	1 ppm
Nitrogen dioxide	0-800 ppm	1 ppm
Nitric oxide	0-2000 ppm	1 ppm
Temperature	0-1100^0 C	1^{0}C

Above tables gives information about metering range of fuel efficiency meter for measurement of different parameters.

IV. EXPERIMENTAL METHODOLOGY

The tests were conducted at a constant speed of 1500 rpm at different loads. The engine was started with diesel or biodiesel blend fuel and warmed up. The warm up period ends when cooling water temperature is stabilized. Then fuel consumption, brake power, brake specific fuel consumption, brake thermal efficiency, exhaust gas temperature etc. were measured. For test, Windows based engine performance analysis software package “Engine-soft” was used.

The emissions of various gases were measured by fuel efficiency meter. It measures the concentration of various exhaust gases such as CO, CO_2, NO_X and flue gas temperature. Based on the obtained results, graphs were plotted. These graphs were later analyzed, referring the available literature.

V. RESULTS AND DISCUSSIONS

When all of the data from the engine are compared, a number of trends involving the effects of biodiesel on engine exhaust emissions.

A.Emission Analysis

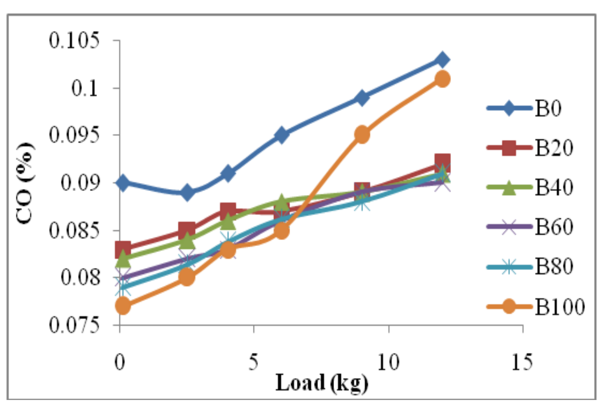

Fig. 4 .Load vs. CO

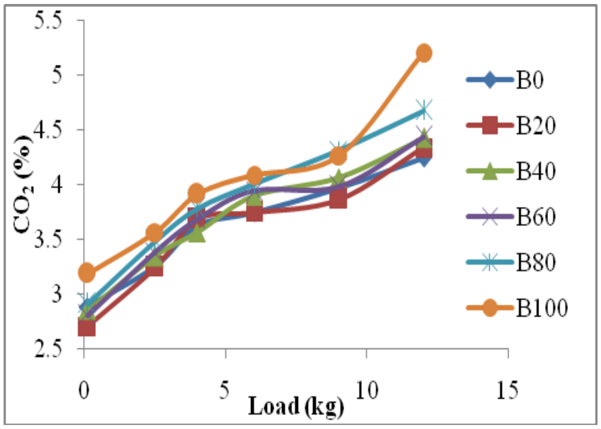

Fig. 5. Load vs. CO_2

Comparative analysis of CO emissions or various blends is shown in Figure 4 For biodiesel mixtures CO emissions is lower than that of diesel fuel. As the amount of biodiesel in the blend increases, the amount of CO emission decreases. This variance is in the range of 8-10%. For biodiesel mixtures CO emissions is lower than that of diesel fuel, because biodiesel mixture contains some extra oxygen in their molecule that resulted in complete combustion of the fuel and supply the necessary oxygen to convert CO to CO_2.CO_2 emissions increase with the use of biodiesel as shown in Figure 5 Blends up to B60 do not show any significant increase in the amount of CO_2 i.e. only about 2% increase than that of diesel is observed. However, for B80 and B100 blends, 7% and 11% increase is observed respectively. This rise is observed due to more efficient combustion of fuel. In case of biodiesel the higher CO_2 emissions should cause less concern because this CO_2 is recovered naturally by raising biodiesel crops. Thus, in the view of life-cycle period of CO_2, biodiesel will cause 50-80% reduction in CO_2 emission compared to petroleum diesel.

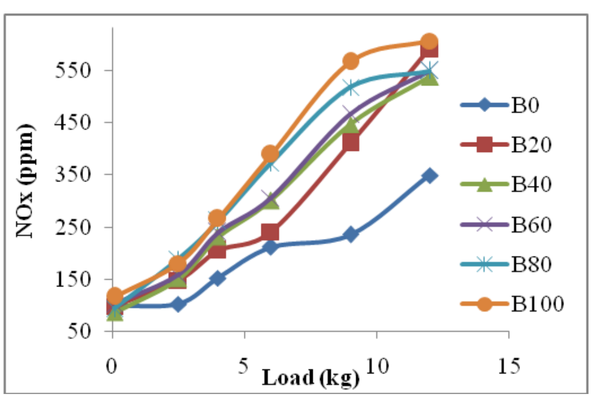

Fig. 6. Load vs. NO_X

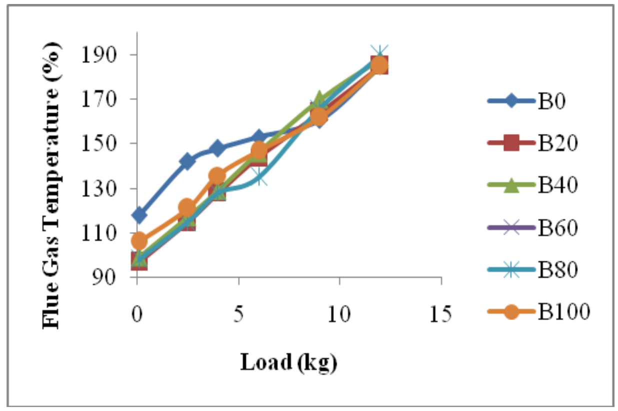

Fig.7. Load vs. Flue Gas Temperature

The variation of NO_x emissions for various blends with respect to load is shown in Figure 6 The emissions increase for biodiesel than that of diesel. This increase is linear with the increase in biodiesel content in blend. Increase is 52-54% for B20 and B40, 60% for B60, 72% for B80 and 85% for B100. This increase is mainly due to higher inherent oxygen content of biodiesel, higher combustion temperatures when biodiesel is used, higher cetane number and different injection characteristics. The graph of flue gas temperature vs. load for the different blends is as shown in Figure 7 For loads higher than 6 kg, the flue gas temperature is more or less similar. For loads up to 6 kg, diesel shows higher flue gas temperature than biodiesel. However, flue gas emitted by B100 has higher temperature than lower blends. This behaviour may be attributed to the higher oxygen content, better lubricity and better combustion characteristics of biodiesel. Because of these factors, heat loss during combustion of biodiesel is less than that of diesel. Most of the energy generated during combustion is utilized as brake power and power lost to the exhaust gas is less.

VI. CONCLUSION

Considering the results obtained from the emission tests it can be concluded that. For biodiesel mixtures CO emissions is lower than that of diesel fuel. As the amount of biodiesel in the blend increases, the amount of CO emission decreases.CO_2 emissions increases with the use of biodiesel. Blends upto B60 do not show any significant increase in the amount of CO_2. This rise is observed due to more efficient combustion of fuel.NO_X emissions increase significantly for biodiesel than that of diesel. This increase is linear with the increase in biodiesel content in blend.Thus when we consider CO and CO_2 emissions, employment of biodiesel can be advocated. However, a notably increased NOX emission is a concern which needs to be addressed to make biodiesel a suitable and feasible substitute for diesel. Therefore, biodiesel can be used in the diesel engines effectively without any engine modifications with any compromise in engine performance. The only hurdle is a higher NO_X emission which needs to be solved by finding some suitable additive to solve this problem.

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