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Emission Reduction by using Linseed & Turpentine Oil Blend as Alternative Fuel in Diesel Engine

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***Abstract*--- As due to the continuously increasing demand for fossil fuels and environmental threat, a number of renewable sources of energy have been studied worldwide. Currently, the limited petroleum reserves are being rapaciously consumed which also leads to various environmental issues. The use of renewable vegetable oils derived from plant seeds has gained attention worldwide due to raise in petroleum-crude prices. Physical and/or chemical transformations are used to improve the vegetable oil properties so to it will be compatible for use in existing engines. Thus, alternative fuels which are renewable and are also which does not cause any harm to environment are being investigated. Considering the world's insatiable ravenousness for petroleum, one of the best large-scale renewable sources are vegetable oils derived from natural plant seeds. Hence by this investigation blend of two bio fuels are used as a fuel in diesel engine. And its performance and emission parameter is measured and compared with diesel.**

Keywords: Linseed oil, Diesel engine, Emissions, Transesterification, Turpentine oil, alternative fuel.

I. INTRODUCTION

Diesel engine was invented by German inventor and mechanical engineer Rudolf Diesel in 1893, and now these engines are everywhere and widely used in industries, and transportation and uses diesel as fuel. Using Diesel as a fuel had some major problems, Since these are the fossil fuels and rate with which are extracting this fuels soon it will reach peak production within few years, then there availability will continuously decrease and it will completely exhausted at the end of this century. With diesel there is an emission of CO, CO_2, SO_x, NO_x, which leads to the pollution and global warming. Public is also aware of their health and the also want some other option than diesel. In the search for alternative, one of the favorable options was found to be renewable fuels like alcohols, vegetable oils, etc. and Bio diesel comes into picture. It will control the emission problem up to some extent, but it is not complete solution .We are using blend of linseed oil and turpentine oil to run the diesel engine and examine the efficiency , Emission and some other parameter of it, compare to diesel engine. Turpentine oil is obtain by distillation of resin which is obtain from live trees, mainly pines. Linseed oil is obtained from the dried, ripened seeds of the flax plants.

- Turpentine oil (less viscous) + linseed oil (viscous)
  0.001375pas sec + 0.0331pas sec

Main objective is to perform an experiment at various Loads on engine by taking the blend of Linseed oil & turpentine oil in a different ratio as a fuel in a single cylinder 4-stroke diesel engine and compare the results and various parameters with using the diesel like emission of CO, SOx, NOx, and hydrocarbon in the exhaust gas. And also compare the indicated power, mean effective pressure and others things to check whether this blend has a potential to replace the diesel or not. The purpose of this experiment is to provide an alternate fuel to the society for diesel engine. Which also having a less emission and have environment friendly. In search of an alternative fuel which is also an environment friendly and are renewable source one of the best option found is the vegetable oils derived from the various natural plants and their respective seeds. But it also has some problems as it cannot be directly used because of their high viscosity, density, and poor volatility of the vegetable oil. Hence it is first converted into the Bio diesel by the transesterification process before using in existing diesel engine. This process reduces the poly-unsaturation of these vegetable oils which leads to diesel like fuel (biodiesel). Both the Linseed oil and turpentine oil are used as a fuel separately by mixed with diesel in CI engine and the engine Performance and there emission were investigated **[1-3].**As with only turpentine oil mixed with a diesel suggested that more than 30% TPOF will give more break power. And with increase in percentage of TPOF emission reduces except CO2 **[4].** The turpentine oil itself should not be used as a fuel since large amount i.e. 85% of it distillates at very narrow temperature band and the main effects obtain by 10%, 20% and 30% of turpentine additions to Gasoline fuel on pollutant formation were that the ratio of NO_x is increased, while that

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of CO decreased. Increasing amount of turpentine in the GLF sample fuel had positive effects on the performance parameters **[5].** To control the emission various bio-diesels are mixed with the diesel and used but complete replacement of diesel is yet to found. The objective of the present investigation is to not only found the fuel which have less emission but also should have a capability to completely replace the diesel completely. For this two different oils having different viscosity Turpentine oil(less viscous) and linseed oil (viscous) are used in different ratio so that there mixture will having close to same properties as diesel in terms of performance but have less emission.

II. EXPERIMENTAL PROCEDURE

A. Fuel Preparation

The main problems encountered with linseed oil as a bio diesel are its high viscosity and very low volatility due to long chain structure it has. Conversion of the vegetable oil as a CI engine fuel can be done by any of the four methods; pyrolysis, transesterification, dilution/blending and micro emulsification, **[6]** **[7].** For this experiment, Transesterification process has been chosen. As the viscosity of linseed oil bio-diesel highly reduces after transesterification process **[8]** **[9].** Linseed bio-diesel produced by this process reduces the poly-unsaturation of these oils and hence has the properties comparable with conventional diesel fuels **[10]** **[11].** Alkali-catalyzed transesterification is one of the most commonly used process for oils with low free fatty acids and less moisture content. Transesterification process composed of three consecutive reversible reactions;

1) Conversions of triglyceride (TG) to diglycerides (DGs),
2) DG to monoglyceride (MG), and
3) MG to glycerol (GLY).

Three moles of alcohol are needed for one mole of mono alkyl ester, obtained in each step. At the end of process Glycerol is acquire as a byproduct. Transesterification reaction is sensitive to some reaction parameters such as the type of alcohol used, their molar ratio to oil (MR), temperature at which reaction occurs(T), type of catalyst and their amount, and the stirring rate (SR) **[12-16].**The material used are Vegetable oils (linseed oil, rice-bran oil and castor oil), NaOH, methanol. Firstly, the required amount of oil was filtered and weighed. Oil was preheated up to the reaction temperature to remove moisture, if it is present. The measured amount of alcohol i.e. methanol and catalyst (NaOH) were mixed properly, at ambient temperature, to prepare a homogeneous solution. Preheated oil and homogeneous solution was poured on a beaker and put the complete system above the heater and magnetic stirrer. It is then stirred at a fixed stirring rate for 5-6 hours till the equilibrium will reach. After that the mixture was poured into the separating funnel and hung out for sufficiently long time i.e. (24 h) to separate due to gravity difference. The upper layer contains mainly the linseed methyl esters (LME), biodiesel (light yellow color), and the lower layer collected at the bottom contains the glycerol (dark color). Glycerol was separated from bottom of separated funnel. And linseed oil as a bio- diesel is collected from the top. The properties of diesel linseed oil, and turpentine oil are shown in table.1.

TABLE 1. Properties of linseed oil/ester and diesel.

Properties	Diesel	Linseed Oil	Turpentine
Formula	$C_nH_{1.5n}$	$C_{18}H_nO_2$	$C_{10}H_{16}$
Specific Gravity	0.834	0.95	0.86–0.9
Kinematic Viscosity at 40 $^{\circ}$C(centistokes)	2.7	26	2
Flash Point($^{\circ}$C)	50	241	38
Pour Point($^{\circ}$C)	—16	—15	< 0
Gross Heat content (kj/kg)	42,700	39,307	44,400
Cetane Number	47	34.5	20-25
Carbon (%)	86	–	–
Hydrogen (%)	14	–	–
Oxygen (%)	–	–	–
Sulfur (%)	0.17	–	–
Nitrogen (%)	–	–	–
Iodine Value	–	184	–

This linseed oil bio diesel is mixed with turpentine oil to form the final required fuel. These fuels are mixed in a different ratio and sample has been made for the experiment as shown below.

- Sample 1, Turpentine oil 60%, Linseed oil 40%
- Sample 2, Turpentine oil 50%, Linseed oil 50%
- Sample 3, Turpentine oil 40%, Linseed oil 60%
- Sample 4, Diesel

Diesel is taken as Sample 4, so that all the parameters and performance obtain by new fuel can be compared with diesel

B. Test Procedure

Experiment has to be conducted on single cylinder, 4 stroke diesel engines. Having a rated power of 5.2 KW @ 1500rpm.An electrical dynamometer of length 185mm was coupled to the engine was used as a loading device. The load and speed can be decreased or increased on the dynamometer and thereby on the engine, by switching on or off the load resistances. The performance parameter and emission is been monitored for each sample of fuel by running the engine at different loads and by maintaining the constant rpm. And the performance parameter and emission of the sample fuel will be comparing with the diesel fuel. Exhaust gas temperature was measured by a thermocouple. nitrous oxide (NOx), carbon monoxide (CO), Oxygen (O2), hydrocarbon (UBHC), carbon di oxide (CO2), and unburned emissions were measured by exhaust gas analyzer (QROTECH) ‘‘QRO-401’’. Fuel consumption was measured by a U-tube manometer. Schematic diagram of the experimental set-up used in this investigation is displayed in Fig.1. with all measuring points and measuring instruments. The technical specification of the engine is given in Tables 2.

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TABLE 2. Specifications of diesel engine.

Make	Kirloskar
No. of Cylinder	One
Stroke	Four Stroke
Type of Cooling	Water cooled
Ignition	Compression Ignition
Fueling	Diesel
Brake Power	5.2 kW
Speed	1500 rpm
Sfc	251g/Kwh
Orifice Diameter	16mm
Dynamometer arm length	185mm

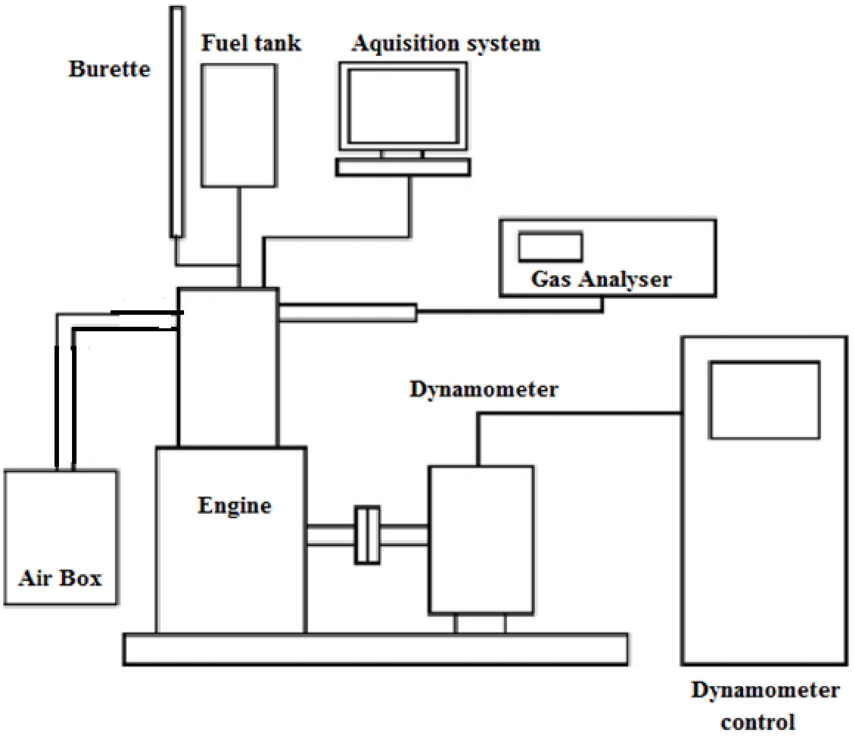

Figure 1. Schematic of experimental set-up.

III. RESULTS AND DISCUSSION

A. Performance

The results of an experiment carried out on a DI diesel engine using a blend of linseed oil and turpentine oil in a different ratio are presented and discussed below and it is also compare with the performance of diesel fuel. As shown in fig. 2. Fuel consumption normally increases with the Engine load, and with the increase in linseed oil fraction in mixture fuel consumption increase. And the overall fuel consumption of fuel each mixture is more than diesel at each load. In fig. 3 Air fuel ratio decrease with the increase in engine load and diesel have more air to fuel ratio at each load than the new fuel. In fig. 4 shows the indicated power at each load, at lower loads diesel gives more indicated power but at higher load new fuel have more indicated power than diesel. Sample 2 has overall more good performance than all other samples. In fig. 5 shows mean indicated mean effective pressure (IMEP) at lower loads diesel have more IMEP, but at higher loads new fuel blends have more IMPE than diesel. Sample 2 has overall better performance.

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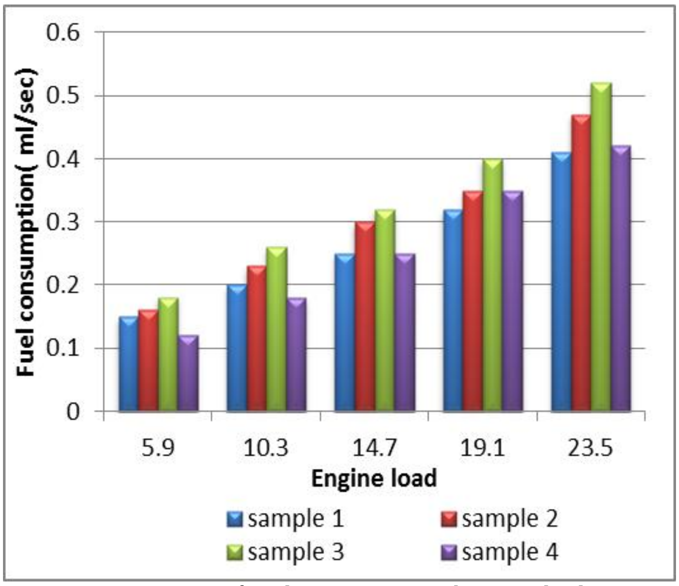

Figure 2. Variation of Fuel consumption with Engine load

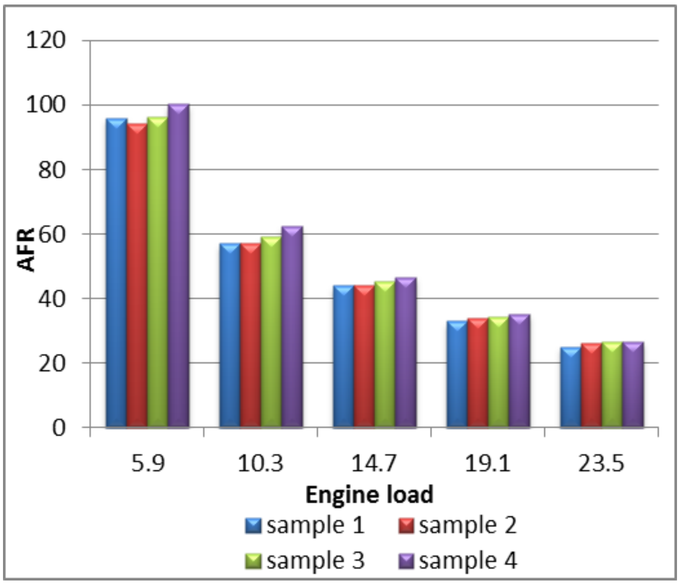

Figure 3: Variation of air fuel ratio with Engine load

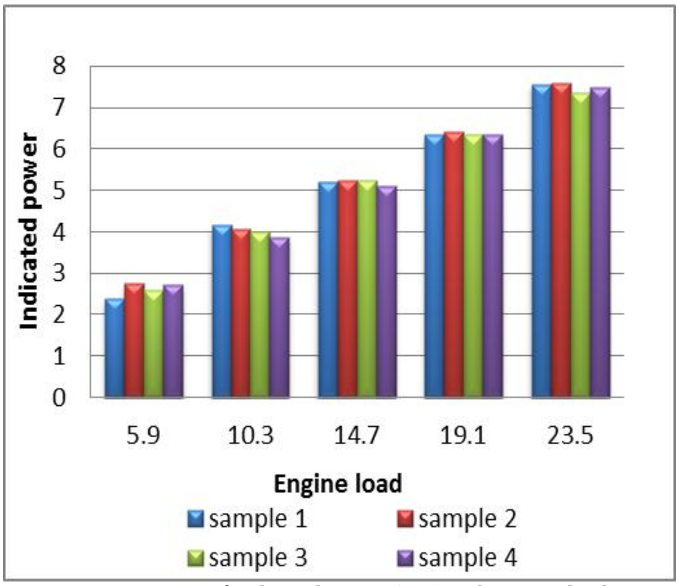

Figure 4: variation of Indicated power (Kw) with Engine load

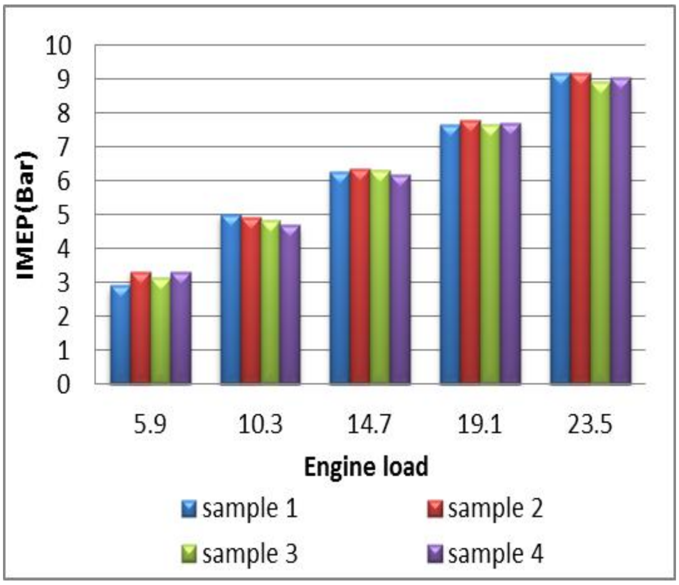

Figure 5. Variation of IMEP with Engine load

B. Emissions

As we seen above performance wise new fuel is almost equal to the diesel and even some sample have more good performance than diesel had. The important emissions from diesel engine such as CO, CO2, HC, and NO were measured and analyzed. As fig. 6 shows the variation of CO with Engine load, at lower loads diesel have low CO than all the other samples, but at higher loads all the samples including diesel have similar emission of CO. Fig. 7 shows the emission of CO2 with the engine loads. It is observed CO2 emission increase with increase in engine load and at each load new fuel has slightly more CO2 emission than Diesel have. Sample 1 has maximum among all other at higher load. Fig .8 shows the emission of unburned hydrocarbon (HC) at different Engine loads, it is observed that at each loads sample 1 has more hydrocarbon emission than others. And it is much higher than others sample at higher loads. It indicates the improper combustion of the fuel. Fig .9 shows the variation of O2 with the engine load. As with the increase in load more O2 participate in combustion hence less O2 is obtain at exhaust. Fig. 10 shows the variation of NO with load it increases with the increase in engine load, at lower loads diesel having the almost same NO at exhaust compare to new fuel but at higher load, Diesel having much higher emission than the new fuel. Sample 1 has least NO emission.

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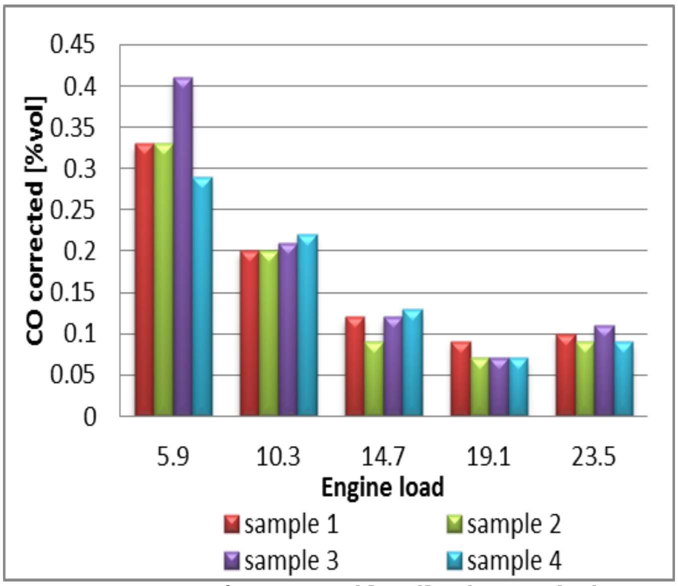

Figure 6. Variation of CO corrected [%vol] with Engine load

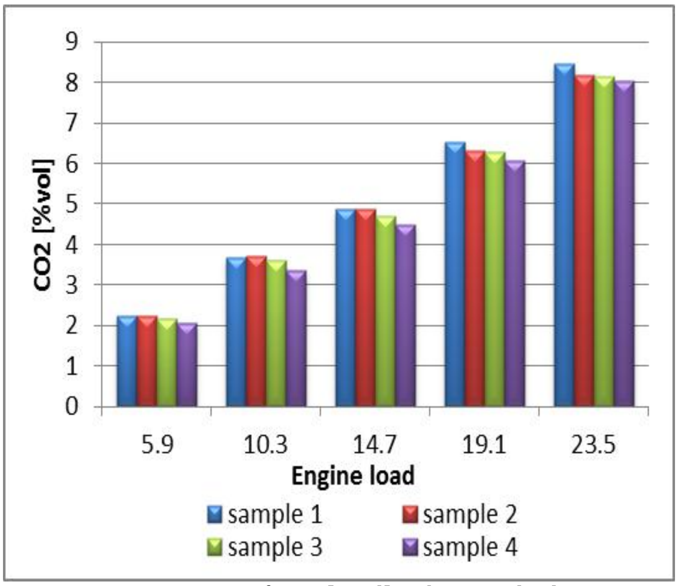

Figure 7. Variation of CO2 [%vol] with Engine load

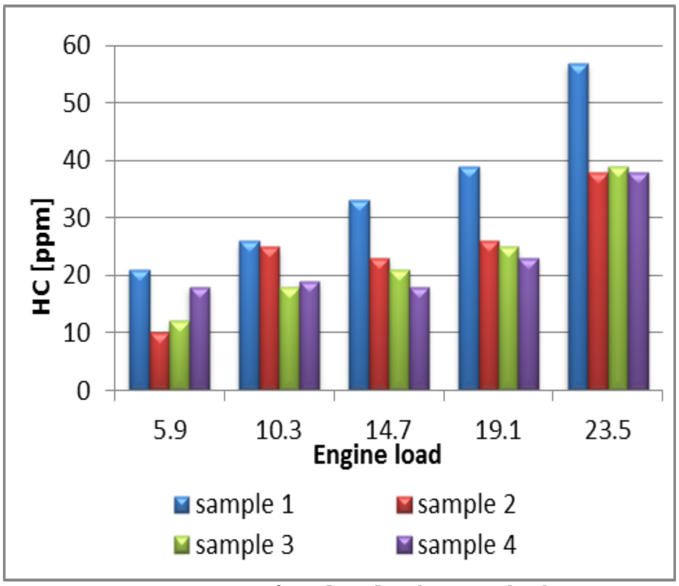

Figure 8. Variation of HC [ppm] with Engine load

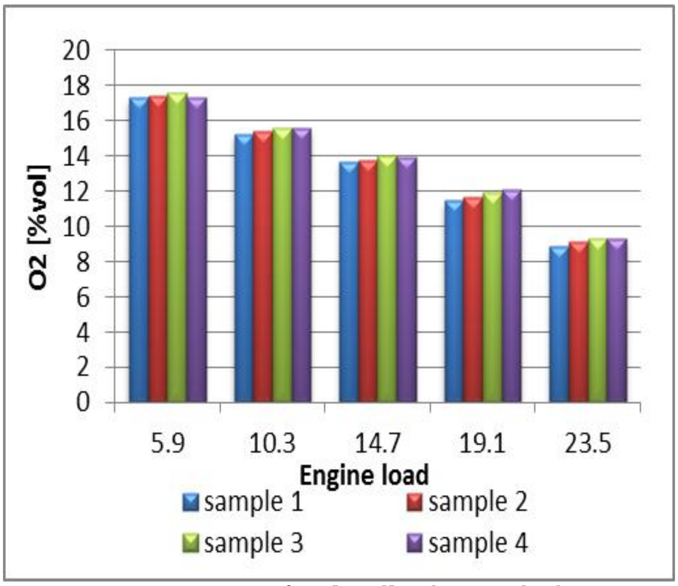

Figure 9. Variation of O2 [%vol] with Engine load

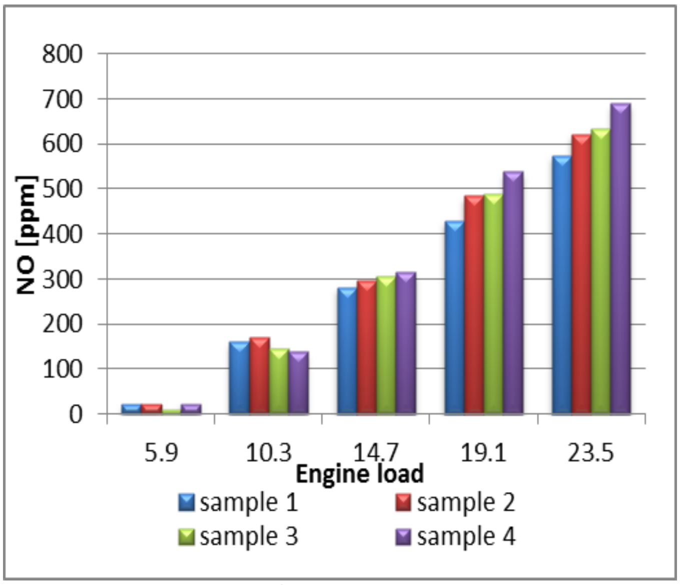

Figure 10. Variation of NO [ppm] with Engine load.

IV. CONCLUSION

From the present investigation it is noticed that the mixture of linseed oil and turpentine oil which is taken as a fuel has a capability to replace the conventional diesel fuel in terms of the indicated power. But in terms of emission it is noticed that the entire sample have a less NO emission then Diesel with higher engine load. These are the following conclusions drawn with respect to different samples.

➢ Sample 1, (Turpentine oil 60%, Linseed oil 40%)

It has more indicating power, and having less fuel expending then other samples. It also has less CO and CO2 at exhaust than any other samples but more than the Diesel. It has lowest NO emission than other sample as well as Diesel. The only disadvantage it has is the high HC at it exhaust, and it became even more at the higher loads.

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- Sample 2, Turpentine oil 50% , Linseed oil 50%

It has almost equal indicated power as sample 1 have, and even more at the lower loads, and it also have greater indicated power then diesel. But it has more fuel consumption than sample 1 and Diesel. CO and CO2 emission is almost equal to sample 1 and even some time lower than that and Diesel also. Having slightly more Emission of NO than sample 1 but less than Diesel, HC emission is lower than sample 1 but higher than Diesel.

- Sample 3, Turpentine oil 40% , Linseed oil 60%

Indicated power is slightly less than sample 1, 2 and from diesel also. It has the highest fuel consumption among all other sample and Diesel. CO emission is higher than other sample and Diesel, CO2 emission is slightly lower than other samples. HC emission is lower than sample 1 but higher than Diesel and having slightly more Emission of NO than sample 1 but less than Diesel.

By considering all the fuel and there performance and emission at different loads it is recommended that the sample fuel is most suitable as it has less NO emission, good indicated power, less HC emission than sample 1.

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