Experimental Parametric Study of Biodiesel to Develop Economic Zero Effluent Discharge (ZED) for Diesel System

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Abstract— *Great demand of renewable energy resources are created because of rapid depletion of petroleum reserves along with increasing ecological concerns. Environmental degradation and depletion of fossil fuels whole world is facing problem. The increasing demand, swift depletion of fossil fuel reserves and uncertainty in shipment, along with the clipping in petroleum prices, has foster the search for other alternatives to fossil fuels. From the cited view, there is an clamant need to find the new alternatives, which allay dependency on oil imports as well as can assist in protecting the environment for sustainable development. Biodiesel has arise as alternative to petroleum origin diesel. Currently lots of alternative fuels are being found as with potential which is against the current high-pollutant diesel fuel obtains from diminishing commercial resources. In recent times biodiesel appears as one of the most energy efficient environmental friendly options to full fill the future energy needs. Already a more efforts taken for source which fulfill the criteria of sustainability and economical carried out. But in case of biodiesel effluent is critical issues. So characterization and formation of biodiesel with zero effluent is prime objective. Thumba is used for formation of zero effluent discharge.*

Keywords— Renewable energy, biodiesel, Thumba.

I. INTRODUCTION

An accretion demand of fossil fuels one of the critical problems facing by world. The natural resources of fossil fuel are slumping day by day. Natural fuel which is biodiesel is main source or alternative or good source and substitute for fossil fuel in future.

Biodiesel can be extracted from non edible oil like Jatrophacurcus, pongamiapinnata, Madhucaindica, Gossypiumarboreum, Simaroubaglauca etc. and more. The main reason behind selection of biodiesel is that they are biodegradable, non-toxic and significantly reduce pollution. Derived fuel from biodiesel leads to massive reductions in particulate emissions. Biodiesel is a safer, more economical and more environmentally friendly than the conventional petroleum diesel.Transesterification is the process which is commonly used for produce biodiesel. It can be produce from variety of vegetable oils and animal fat. At the end of transesterification byproduct formed is Glycerin. To reduce the effluent to achieve maximum yield of biodiesel, zero effluent discharge system is used.Thumba oil is selected as it underutilized non-edible vegetable oil. Availability in large quantities in western India and its capacity and suitability as a biodiesel feedstock is yet not measured comprehensively. Thumba as promising alternative fuel which is hydrocarbon based fuels to full fill the future energy needs. It was concluded that Thumba methyl ester may works as a sustainable feedstock for biodiesel production that is equivalent to fossil fuel as per ASTM 6751.

II. LITERATURW REVIEW

In the recent years, serious efforts have been made by several researchers to use different sources

Ma F, Hanna MA

Showed viscosity is unfavorable physical property and which restrict the use of straight vegetable oils as a biodiesel. Due to higher viscosity, vegetable oil causes incomplete combustion, poor fuel atomization and carbon deposition on the injector and valve seats. This resulting in serious engine fouling. To overcome the problem of higher viscosity one possible method is blending of vegetable oil with diesel in proper proportion.Transesterification is also used for produce biodiesel. [1]

Peterson CL et.al

Study reported that the transesterification process has been effective method of biodiesel production and viscosity reduction of vegetable oil. It was observed that transesterification process influence by temperatures, catalyst type, concentration ratio of alcohol to fuel and stirring speed rate a greater extent. [2]

Masjuki HH et.al

This study revealed that practical alternative fuel for older in-service engines. , it was observed that the vehicles had some improved power performance by the use of biodiesel. for coconut oil with blend (50/50 blend) very less amount of particulate matter use of this fuel. [3]

Ramadhas AS et.al.

It found that using blend 20 there was no luminous engine problems were reported in tests with urban bus fleets running.

2–5% Fuel consumption of biodiesel blend higher than that of conventional diesel.Fuel economy was comparable with diesel. Ester blends have been reported to be stable, and did not separate at room temperature over a period of three months. Limitation of the use of biodiesel is it is crystallize at low temperatures below 0^0C.[4]

Wagner et al.

Test conducted on soybean oil ester fuel on John Deere (4239T Model) engine. It was showned that the engine performance with methyl, ethyl and butyl esters which was closely same as that with diesel fuel. Emissions of oxides of nitrogen were significantly higher for the esters. It concluded that esters could be used on a short-term basis, and that further testing to be done for determining long-term ester fuel effects. [5]

Ryan and Bagby

Found that the vegetable oils (peanut, sunflower, cottonseed and soybean oils) reveal characteristics opposite to those expected in most other fossil fuels. For this purpose, an alternative liquid fuel that will blend readily with diesel fuel is required Many researchers have studied performance and emission characteristics of undi oil blended with diesel. [6]

C. Srinidhi et al.

Experiment analysis carried out for performance parameter and emission characteristics (NOx, HC, CO. etc.) is obtained for various bio diesel and diesel blends. Also comparative study done on with ordinary diesel at various loads on a modified variable compression ratio CI engine. The results shows that the performance and emission characteristics of the engine fuelled with Honne oil methyl ester – diesel blends is comparable to diesel. [7]

Bawane et al.

Performed experimental work to obtain the operating and emission characteristics of Undi Oil Biodiesel on Variable Compression Ratio (VCR) engine run on various blends of biodiesel, compression ratios and load conditions. From the comparison of results, it is inferred that the engine performance is improved with reduction in emissions for the chosen oils without any engine modification. [8]

Bawane et al.

Experimental Investigation carried on on CalophyllumInophyllum Biodiesel in CI Engine by Varying Compression Ratio. Results showed that it is inferred that the engine performance is improved with significant reduction in emissions for the chosen biodiesel without any engine modification. [9]

S.Sundarapandian and G.Devaradjane et al.

Evaluated the heat release and work done are reduced by about 4% for Jatropha, 5% for Mahua and 8% for Neem oil esters when compared to diesel. Thus the developed model is highly compatible for simulation work with biodiesel as alternative fuel [10]

Chavan S B et al.

Conducted an experiment, concluded on Undi.Seed characterization - Fresh seeds contains moisture 12%, the available oil percentage in Undi seeds is 55-75%. As per experimental trial, recorded 52% of oil.Physico- chemical Properties - The fresh extracted crude oil is greenish yellow and it get darkened during the storage. [11]

G Basavaraj et al.

In this work for promotion of biofuels the policy framework which is very encouraging, experience has show that the government's initiatives have not translated into results on the production and commercialization fronts to meet the country's energy demand. [12]

E. Sivakumar, R. Senthil, R. Silambarasan, G. Pranesh, S. Mebin Samuel

In this work, the blends were prepared on volume basis, in the proportion of 20%, 40%, 60%, 80% Thumba oil methyl ester with diesel.Results showed that, brake thermal efficiency increases with the increase in load. Brake thermal efficiency decreases with the increase in the concentration of the Thumba oil in Thumba oil methyl ester – diesel blends. Diesel has lower brake thermal efficiency compared with the Thumba oil methyl ester – diesel blends. [13]

Sunilkumar R. Kumbhar, H. M. Dange

Conducted experiments on performance analysis of single cylinder diesel engine, using diesel blended with Thumba oil. Thumba B100 showed better emission performance of CO2 than other blends of Thumba biodiesel at all compression ratios. For all the compression ratios ppm of NOx coming from pure diesel was less than all other blends of Thumba biodiesel. At CR 18 Thumba B20 Showed better emission than other blends of Thumba biodiesel.[14]

Vandana Kaushik, Dr. O. P. Jakhar, Dr. Y. B. Mathur

Conducted experiments on performance analysis of lower concentration blends of Thumba methyl ester with diesel. In this work, performance were obtained with Thumba methyl ester blends with diesel in different proportions such as TME10, TME20, TME30 and optimization of engine operation using different Thumba methyl ester blends (TME10, TME20, TME30) was carried out in terms of compression ratio. Results showed that, the brake thermal efficiency increases with increasing of engine load for diesel fuel as well as for all the blends tested. Higher brake thermal efficiency was observed for diesel fuel engine operation for entire load range compared to all Thumba methyl ester diesel blends.[15]

Y. B. Mathur, M. P. Poonia, U. Pandel and Shiv Lal, V. K. Gorana, N. L. Panwar

Conducted experiments on comparative study of Thumba seed biodiesel. In this work, five blends B05, B10, B15, B20 and B25 of Thumba seed oil biodiesel were papered and performance was evaluated with 7HP four-stroke diesel engine. The performance of Thumba seed oil biodiesel were compared with biodiesel prepared by mustard, castor and

Jatropha seed oil with same blends. Results showed that, for all blends tested, brake specific fuel consumption was found to decrease with increase in BHP. Thumba seed biodiesel blends (B20) shows comparable mechanical efficiency with other biodiesel. ISFC of Thumba seed biodiesel was lowest at B25 for all loads. **[16]**

III. LITERATURE OUTCOMES

From the experimental studies conducted by amply of scientists and researchers, it has been observed that the oils extracted from seed crops to produced vegetable oils have high energy content and perusing good fuel properties, but processing require to form biodiesel so that it can use in engines. From literature it shows that the transesterification process is most suitable and acceptable method for biodiesel production

Although various work has been done on various out on vegetable oils like jatropha oil, karanja oil, sunflower oil, soya oil etc. and evaluation of performance characteristics, emissions are observedbut it was observed that very few amount of work has been done to evaluate performance, emission characteristics and combustion analysis of diesel engine using Thumba oil. Also no work has been done to form biodiesel with less effluent or zero effluent.

Literature reviews helped to explore understanding of transestrification. It gives the preeminent solution to formulate new methodology and techniques for proposed work. Zero effluent will be best suitable to for further research in current field. This scrutiny gives stimulation for research work to generate new methodology to find out biodiesel with zero effluent discharge.

IV. THUMBA

Citrulluscolocyntis, commonly known as the colocynth,is a member of theCucurbitaceous family closely related to watermelon. Citrullus colocyntisis known as Indrayanin Hindi or Bitter apple in English. Cucurbitaceous is consists of about 100 genera and 750 species. This plant is known for its great genetic diversity and lengthy adaptation which covers tropical andsubtropical regions, arid deserts and temperate locations. Cucrbits are ostentation for their high protein and oilcontent. The seeds are sources of oils and protein with about 50% oil and up to 35% protein. Thumba is a drought-tolerant species having deep root system.

Thumba oil is a non edible vegetable oil. Western Rajasthan and Gujarat are the places where mostly Thumba found. Thumba (Citrulluscolocyntis) seeds contain 20-30% oil in it. In India biodiesel production is carried on jatropha and other vegetable seeds corps. Thumba is one of the recent crop useful to form biodiesel. The plant is in the form of climbing plant and cultivates well in sandy soil, plant has annular and rough trunks, rough leaves which are 3 to 7 lobed, 5-10 cm long in middle. Flowers are monolecious and have yellow round fruit . It is found wild in the warm, arid and sandy parts throughout India, up to 1,500 m. It is most abundant in north- western plains of India, especially in the Barmer, Bikaner, Jaisalmer and Jodhpur districts of Rajasthan, and in Gujarat. Thumba normally accrue in rainy season. Thumba seed obtainable in summer season.

METHODOLOGY:-

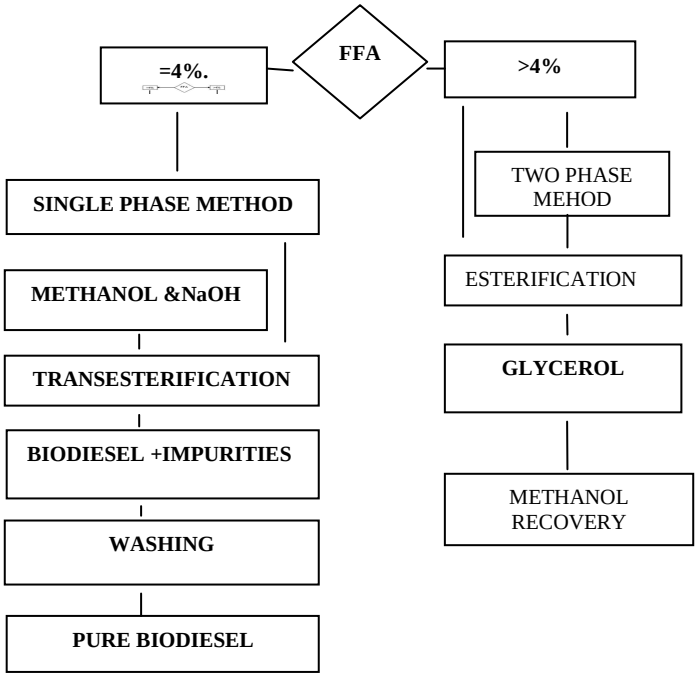


Fig.1:Showing Methodology of ZED Biodiesel Formation

Seeds are de-shelled and dried at temperature at 100-105^{o}C for time period of 30 min in oven. Processed seeds going for extraction through mechanical expeller at room temperature. Thumba oil is first filtered and taken to remove moisture. Oil is kept in an oven at 105^{o}c for 2-3hrs to remove the water content from the oil. The oil was the processed for property testing. Standard titrimetry methods is used to determined free fatty acid content of raw oil and products after reactions (ASTM-664).

Oil containing greater than 4 % Free Fatty Acids go through an acid Esterification process to increase the yield of biodiesel.

Thumba reacted chemically with an methanol to produce esters. The catalyst, sulfuric acid, is dissolved in methanol and then mixed with the pretreated oil. The mixture is stirred, heated , and the Free Fatty Acids are converted to biodiesel. After completion of reaction it is dewatered.

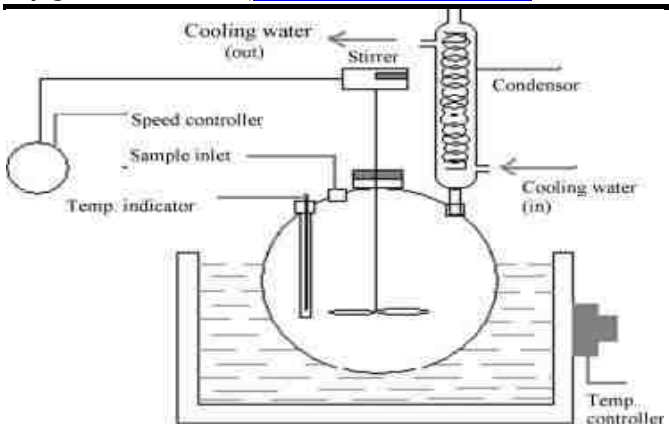
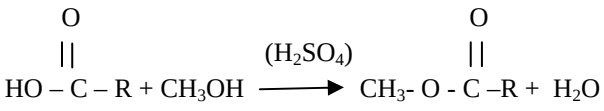


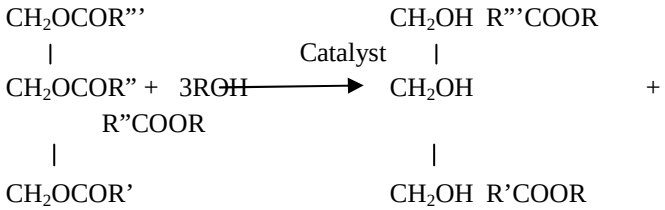
Fig.2: Showing Esterfication Process Setup



Fatty Acid Methanol Methyl Ester Water

Chemical reaction for Esterification

Currently Thumba biodiesel is produced by a process called transesterification where the Thumba oil is first filtered, then processed with alkali to remove free fatty acids. It is then mixed with an alcohol (methanol) and a catalyst (sodium hydroxide). This transesterification process can also be carried out in presence of acid catalyst. The only problem with acid catalyzed process is that it is very slow.



Oil or Fat Alcohol Glycerin
Biodiesel

Chemical Reaction For Tranesterification

Fig.3: Showing Transesterification Laboratory set

V. ZERO EFFLUENT DISCHARGE PROCESS

The catalyst, 2.5 wt % of calcium oxide (chemical based), is dissolved in methanol (8:1 molar ratio) and then mixed with and the pretreated oil and agitated it with 650 rpm. Once the reaction is completed, unreacted methanol is removed by distillation then after biodiesel and glycerin are allowed to settle and it was separated after 8-10 hrs.

Transesterification of triglycerides fatty acid into alkyl esters and glycerol. The glycerol layer which is negligible settles down at the bottom of the reaction vessel. Diglyceride and Monoglyceride are the intermediates in this process.

Once the reaction is complete, major product exists: biodiesel. The reacted mixture is sometimes neutralized at this step if needed. The glycerin produce in this process is zero or very negligible amount (about 4 %) is much denser than biodiesel phase and the two can be gravity separated with glycerin simply drawn off the bottom of the settling vessel. Centrifuge is also used to separate the two materials faster.

Fig.4: Showing Pure Biodiesel

Removal of water from Methyl ester by drying in oven at 100°C temperature. Finally get pure biodiesel (B100).

PREPARATION OF BLENDS OF BIODIESEL:

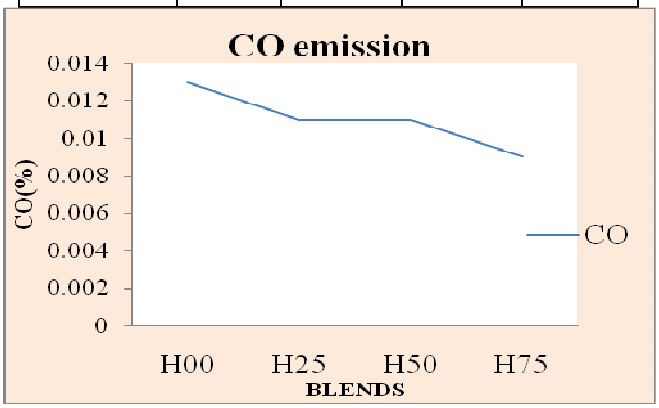
The biodiesel blended with diesel by volume as B10 (10% Thumba biodiesel & 90% diesel fuel) is prepared as- first 90% (900ml) of diesel fuel was taken in reactor vessel then 10 %(100ml) biodiesel was introduced in the same vessel. The mixture is then stirred (550rpm) at 40^{o}C for 20min.Other blends was prepared as same method B20 (20% Thumba biodiesel & 80% diesel fuel), B30 (30% Thumba biodiesel & 70% diesel fuel), B40 (40% Thumba biodiesel & 60% diesel fuel), B50 (50% Thumba biodiesel & 50% diesel fuel), B100 (100% Thumba biodiesel & 00% diesel fuel).

VI. RESULTS

The exhaust gas parameters such as CO, CO2, HC (ppm), Nox, O2 obtained with H00, H25, H50, and H75 are found to be affected by fuel blend and engine loading and are discussed in the following sections. Observation

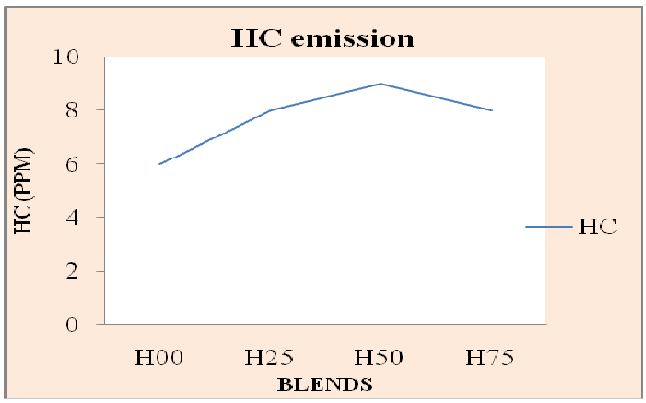
Table.1: Showing Exhaust Gas emissions at blends of Biodiesel

EXHAUST Gases	BLENDS			
	H00	H25	H50	H75
CO (%)	0.013	0.011	0.011	0.010
HC(ppm)	6	8	9	8
CO_2(%)	3.48	2.2	2	1.8
O_2(%)	17.51	18.22	19.43	19.69
NO_x(ppm)	160	171	173	177



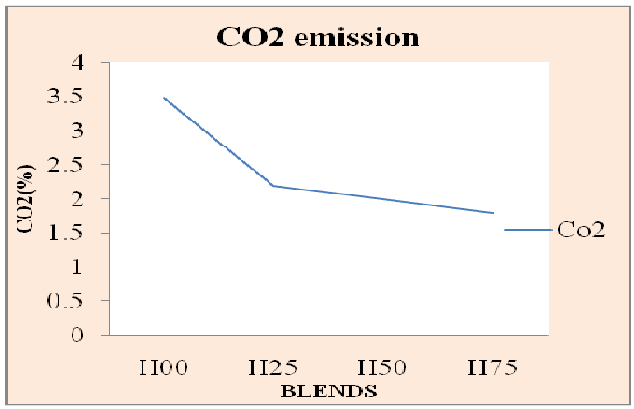
Graph.1:Showing CO Emissions at various blends of Biodiesel

shows that variation in CO emissions with respect to blends of biodiesel. From the graph it is shows that at the blend H00 the CO emission is near about 0.013%, at the blend H25 and H50 the CO emission is near about 0.011% and at blend H75 the CO emission is near about 0.009%. Hence it can be said that CO emissions reduces as blends of biodiesel increases.



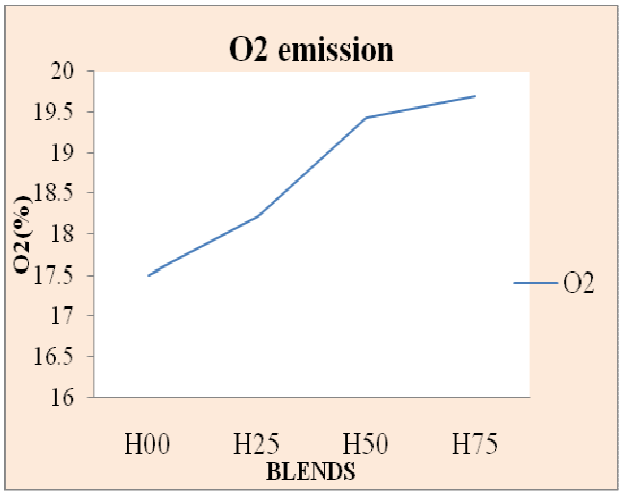
Graph.2:Showing HC emissions at various blends of biodiesel

shows that variation in HC emissions with respect to blends of biodiesel. From the graph it is shows that the HC emission for blend H00 is near about 6 ppm, at the blend H25 the HC emission is near about 8 ppm, at blend H50 the HC emission is near about 9 ppm and at blend H75 the HC emission is near about 8 ppm. Hence it can be said that HC emissions for biodiesel and its blends are more than that of pure diesel.



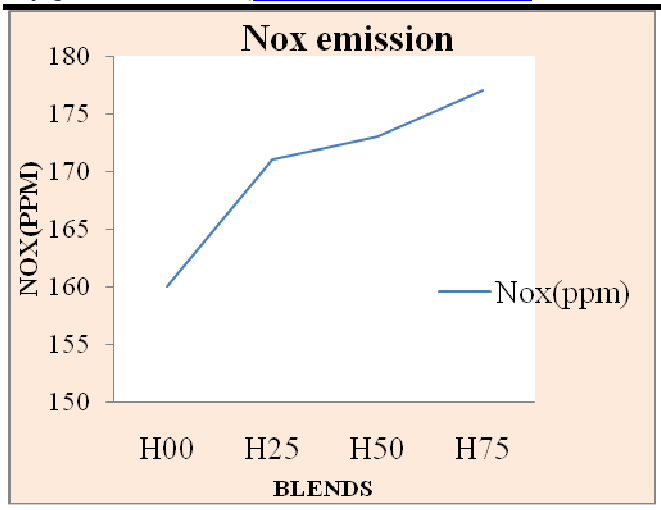
Graph.3: Showing CO_2 emissions at various blends of biodiesel

shows that variation in CO_2 emissions with respect to blends of biodiesel. From the graph it is shows that at the blend H00 the CO_2 emission is near about 3.5%, at blend H25 the CO_2 emission is near about 2.3%, at blend H50 the CO_2 emission is near about 2% and at blend H75 the CO_2 cemission is near about 1.8%. Hence it can be said that CO_2 emissions reduces as blends of biodiesel increases.



Graph.4: Showing O2 emissions at various blends of biodiesel

shows that variation in O_2 emissions with respect to blends of biodiesel. From the graph itis shows that at blend H00 the O_2 emission is near about 17.5%, at blend H25 the O_2 emission is near about 18.4%, at blend H50 the O_2 emission is near about 19.5% and at blend H75 the O_2 emission is near about 20%. Hence it can be said that O_2 emissions increases as blends of biodiesel increases.



Graph.5: Showing NOx emissions at various blends of biodiesel

shows that variation in NOx emissions with respect to blends of biodiesel. . From the graph it is shows that at blend H00 the Nox emission is near about 160ppm, at blend H25 the Nox emission is near about 172 ppm, at blend H50 the Nox emission is near about 174 ppm and at blend H75 the Nox emission is near about 176 ppm. Hence it can be said that NOx emissions increases as blends of biodiesel increases.

VII. CONCLUSION

- Transesterification reactions are seems the most concede reaction pathways to form biodiesel. Vegetable oils, waste oils, animal fats, and waste greases such type of feed stocks that contains free fatty acids or triglycerides can be converted into biodiesel by transesterification process.
- Homogenous blends can be achieved as Thumba biodiesel can be mixed with diesel fuel easily. Moreover, no phase separation was observed for prepared blends.
- In the present study, a series of experimental investigations carried out to explore the performance, combustion and emission characteristics with optimization of engine operation using Thumba biodiesel and its blends.
- On a wide range of specified blends of Thumba oil diesel engine performed smoothly and satisfactorily. No undesirable combustion was observed during the investigation.
- Satisfactory performance and emission characteristics are found at lower content of Thumba oil and in blends,
- Thumba oil can also be used in engines without any major modifications.
- The 25% content of Thumba biodiesel in diesel was found to be optimum concentration of biodiesel in the blend. Moreover, higher concentration blends up to 50% Thumba biodiesel in diesel may be used in diesel engines since, satisfactory performance and emission behavior of the engine was achieved up to 75% Thumba biodiesel diesel blends. Almost comparable performance and lower emissions to that with diesel fuel were observed for low concentration Thumba biodiesel blends.
- Appreciably by around 53.34% hydrocarbon emissions are lowered, as a result of utilization of optimum biodiesel blends in the engine.
- Optimum biodiesel blends evince about 10% reductions in carbon monoxide emissions compared to diesel fuel.
- The engine performed quite well when fuelled with Thumba biodiesel and its various blends, in addition to this the characteristics of Thumba biodiesel are also very close to mineral diesel, therefore, Thumba biodiesel becomes a strong candidate to replace or substitute the diesel in compression ignition engines.
- Thumba biodiesel produced with zero effluent to produce pure biodiesel which in turns increase the efficiency.

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