Performance Analysis of single Cylinder Diesel Engine, Using Diesel Blended with Thumba Oil

Sunilkumar R. Kumbhar, H. M. Dange

***Abstract*—Depletion of nonrenewable source of energy (fossil fuels like petroleum, coal and natural gas) many researchers are looking forward to find an alternative source of renewable energy. One such alternative to diesel fuel is biodiesel. Biodiesel can be defined as fuel comprising of mono alkyl ester of long chain of fatty acid derived from vegetable oil or animal fat.**

So, there is an increasing interest in India to search for suitable alternative fuels that are environmental friendly. Environmental concerns and limited amount of petroleum resources have caused interests in the development of alternative fuels for internal combustion (I.C.) engines. As an alternative, biodegradable, renewable and sulphur free biodiesel is receiving increasing attention. The use of biodiesel is rapidly expanding around the world, making it imperative to fully understand the impacts of biodiesel on the diesel engine combustion process and pollutant formation. Therefore, in this study, the performance test of a variable compression diesel engine with neat diesel fuel and biodiesel mixtures was carried out.

Experiments are carried out by using dual biodiesel blends and compared it with diesel fuel characteristics. The literatures were focused on single biodiesel and its blends. So far a very few dual biodiesel blends of oils have been tried on diesel engine leaving a lot of scope in this area. This paper investigated the performance and emission characteristics of various dual biodiesel blends (mixture of biodiesel and diesel fuel) of Thumba biodiesel on a single cylinder variable compression ratio diesel engine having bore diameter 87.50mm, developed power 3.5kw at 1500rpm, compression ratios 12 to 18, stroke length 110mm, water cooled engine. The biodiesel blends of B10% (combination of Diesel 90% by volume, biodiesel 10% by volume) and B20% (combination of Diesel 80% by volume, biodiesel 20% by volume) gave better brake thermal efficiency and lower brake specific fuel consumption than other biodiesel blends. The blends of B10% and B20% have superior emission characteristics than other blends and closer to diesel values. From the experimental results obtained, Thumba oil blends are found to be a promising alternative fuel for compression ignition engines. At CR 18 BTE and BSFC of Thumba B10, B20 and BP of Thumba B40 showed better performance.CO, HC, CO2 of B100 of Thumba biodiesel showed less emission percentage/ppm, for NOx emission B10 and B20 of Thumba, biodiesel showed less emission ppm.

***Index Terms*— Biodiesel, Blends, Thumba Biodiesel, Engine performance, Emission characteristics**

I. INTRODUCTION

India is home to 1.2 billion people, who are about, 17% of world population, and its thirst for energy is unquenchable. One harsh result of its meteoric growth is the widening gap between the energy produced and energy required by the country. On an average India produces about 826,000 barrels of oil per day and requires about 3,319,000 barrels of oil per day (2010) (statistical review of world energy, 2011).

Further, with the growth of human population and industrialization there will steadily increase in energy demand. Major sources of energy are petroleum, coal, and natural gas which are non-renewable source of energy. Due to the increasing demand of energy all over the world had lead to depletion of non-renewable source of energy. Biodiesel does not contain petroleum, but petroleum can be mixed to produce a biodiesel blend (e.g. B20, B50) that can be used in many different vehicles. Pure biodiesel fuel (i.e. B100) though, can only be used in diesel engines. Biodiesel is biodegradable and non-toxic, making it so safe that it is even safer than the commonly used table salt.

II. BIODIESEL

Biodiesel is defined as a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats. It can be directly used in the compression ignition engine. Biodiesel fuel is a clean burning alternative fuel that comes from 100% renewable resources. Many people believe that the biodiesel is the fuel of the future. Sometimes it is also known as biofuel. Biodiesel does not contain petroleum, but petroleum can be mixed to produce a biodiesel blend i.e. B20 (20% biodiesel and 80% petroleum), B50 (50% biodiesel and 50% petroleum) that can be used in many different automobiles. Pure biodiesel fuel B100 though, can only be used in diesel engines. Biodiesel is biodegradable and non-toxic, making it so safe that it is even safer than the commonly used table salt.

Biodiesel can be used in its unaltered form in diesel engines must be modified and used only in combustion-ignition engines. This makes biodiesel one of the easiest alternative fuels to use. In fact, it is a great option for use on farms in farm equipment. Biodiesel fuel is made through a process called transesterification. This process involves removing the glycerin from the vegetable oil or fat. During the process byproducts are left behind, including methyl esters and glycerin. Biodiesel is free from such substances as sulfur and aromatics which are found in traditional fuels. Biodiesel is made using an alcohol like methanol and a chemical process that separates glycerin and methyl esters (biodiesel) from fats or vegetable oils. Glycerin is used in many common products including soap and is highly marketable; therefore there is little waste in the process. That said, growing crops requires time and significant investment, and the fuel must be made and shifted to a local station.

For these reasons biodiesel is more expensive than

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petroleum. This must be considered against the many economic advantages, however, that arise from a domestic form of fuel, a cleaner environment, an improvement in air quality, and a reduction of cancer-causing agents.

Compared to other alternative fuels, biodiesel has a number of unique features and qualities. It has passed all the health effects testing requirements, unlike other alternative fuels. This means it meets the standards of the 1990 Clean Air Act Amendments. The Environmental Protection Agency (EPA) has legally allowed Biodiesel to be sold and commercially distributed. The rest of the alternative fuels cannot be sold commercially as motor fuel because they do not meet the EPA's fuel specifications. World transport is totally depending upon the fossil fuel, such as oil, natural gas and coal. Diesel engine is mostly used as power source in medium and heavy duty applications due to their lower fuel consumption, lower exhaust emission of carbon monoxide and unburned hydrocarbon compared with fossil fuel. Diesel is mostly used in industrial as well as transportation sector. An Agriculture country like India required huge amount diesel for running the water pump based on diesel engine. Design Variables

III. THUMBA (CITRULLUSCOLOCYNTIS)

Citrulluscolocyntis, commonly known as the colocynth, desert gourd, wild guardh Citrulluscolocyntis closely related to watermelon, is a member of the Cucurbitaceous family. Cucurbitaceous is a large family which consists of nearly 100 genera and 750 species. This plant family is known for its great genetic diversity and widespread adaptation which includes tropical and subtropical regions, arid deserts and temperate locations. Cucrbits are known for their high protein and oil content. The seeds of cucurbits are sources of oils and protein with about 50% oil and up to 35% protein. This plant is a drought-tolerant species with a deep root system, widely distributed in the Sahara-Arabian deserts in Africa and the Mediterranean region.

It is native to the Mediterranean Basin and Asia and is distributed among the west coast of northern Africa, eastward through the Sahara, Egypt until India and reaches also the north coast of the Mediterranean and the Caspian seas. It grows also in southern European countries as in Spain and on the islands of the Grecian archipelago. On the island of Cyprus it is cultivated on a small scale; it has been an income source since the 14th century and is still exported today. It is an annual or a perennial plant (in wild) in Indian arid zone and has a great survival rate under extreme xeric conditions. In fact, it can tolerate annual precipitation of 250 to 1500 mm and an annual temperature of 14.8 to 27.8 °C. It grows from sea level up to 1500 meter above sea level on sandy loam, sub-desert soils, and sandy sea costs with a pH range between 5.0 and 7.8.The plants grow in tropical deserts, wet forests as well as cool temperate moist regions. It can tolerate an annual precipitation ranging between 3.8 to 42.9 dm. The average precipitation tolerance extends up to 11.9 dm. The annual temperature required for growing these plants should ideally range between 14.8°C and 27.8°C. Bitter apple plants are highly xerophytic and grow well in areas with an annual rainfall ranging between 25 cm and 37 cm. The plants require sandy loam soils to thrive well. They can also grow efficiently on sub-desert soils as well as along sea coasts with Ph range between 5.0 -7.8.

IV. PREPARATION OF BLENDS OF BIODIESEL

At present the amount of biodiesel available is less than that of diesel. 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 40oc for 15min.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)..

Fig. 1 Preparation of Blends of Biodiesel

Fig. 2 Thumba Biodiesel Blends

V. MEASUREMENTS OF FUEL PROPERTIES

The important physical and chemical properties of Thumba biodiesel such as density(D), viscosity (V),

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cetane number (C), calorific value(Cl), ash content(Ash),flash point(Fl), fire point(Fr), were determined by ASTM standard methods at Indian Biodiesel Corporation, Baramati and all parameters were compared with the diesel. The different properties considered are as follows.

Table.1 Properties of Thumba biodiesel blend

Sr. No	Test	Ref. Std. ASTM 6751 -	Reference		Thumba Biodiesel Blends					
			Unit	Limit	B10	B20	B30	B40	B50	B100
1	D	D1448-1972	Kg/m3	850 - 900	852	860	870	875	882	891
2	V	D 445-73	Cst	3.0-6.1	3	3.4	3.6	3.9	4.4	5.3
3	C	D 613	-	41-55	49.7	50.2	50.6	50.7	51.6	52
4	Cl	D 6751	MJ/Kg	34-45	43.5	44.1	44.9	45.2	45.4	42.5
5	Ash	D482	% wt	0.1 max	ND	ND	ND	ND	ND	0.1
6	Fl	D 93	°C	120 - 170	74	82	90	94	103	174
7	Fr	D 93	°C	130 - 185	86.7	91.5	93.1	96	106	187.5

VI. ENGINE SPECIFICATIONS

A single cylinder, four strokes, water cooled, constant speed, computer controlled, multi fuel, variable compression ratio engine was selected for the tests. Technical specifications of the test engine are given in Table 2. And the Fig.3 shows the schematic diagram of the experimental set-up.

Fig.3 Test Set up

Table.1 Technical Specifications of Engine

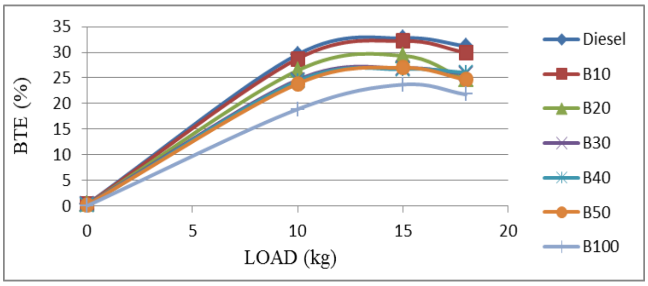
Model	Research diesel engine
Type	Four stroke (CI) Diesel engine, water cooled
No. of cylinders	single cylinder
Cylinder diameter	87.5mm
No. of strokes	4
Bore	87.50mm
Speed	1500 rpm
Power	3.5kw
Compression ratio	12-18
Swept volume	661.45 cc
Stroke length	110 mm
Connecting Rod Length	234mm
Dynamometer arm length	185mm

VII. EXPERIMENTAL PROCEDURE

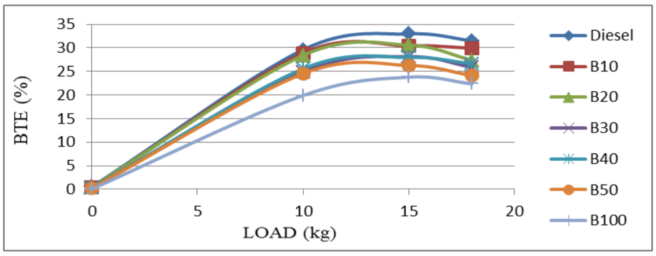
All tests were carried out on the diesel engine as a fuel in order to provide base line data. During the trial speed of the engine was kept almost constant at 1500 rpm and the load on the engine is given as 0 kg,10 kg, 15 kg,& 18 kg. First the compression ratio of the engine was kept as 14 to 18 and then the blends of Thumba B10, B20, B30, B40, B50, B100 were used as fuel in engine.

VIII. GRAPHS

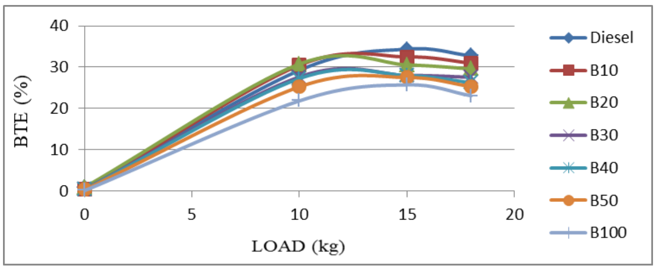
The experiments were carried out by operating the Single Cylinder VCR Engine with pure diesel fuel and biodiesel blended fuels of Thumba with varying compression ratio from 14 to 18. During the test the speed of the engine was trying to keep almost constant i.e.1500 rpm. The parameters were measured during these tests at steady state working condition from the measured parameters the performance parameters computed and they were compared with pure diesel. Following are the performance parameters: brake thermal efficiency (BTE), brake specific fuel consumption (BSFC),brake power(BP),carbon monoxide(CO %),hydro carbon (HC ppm), carbon dioxide (CO2 %), oxides of nitrogen (NOx ppm).



Graph 1 Variation of BTE with Load for Thumba CR 14



Graph 2 Variation of BTE with Load for Thumba CR 15



Graph 3 Variation of BTE with Load for Thumba CR 16

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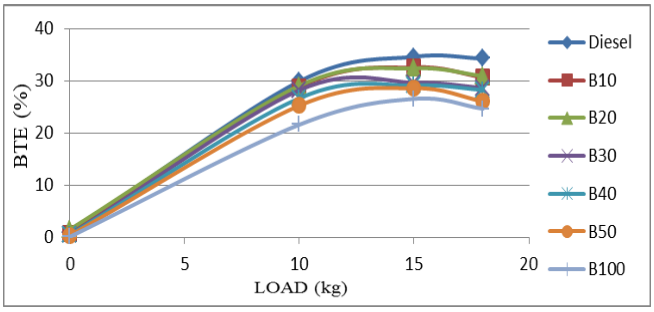
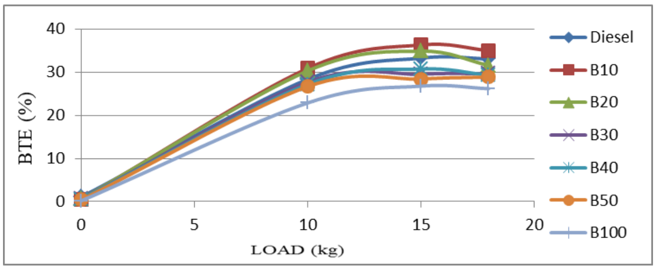
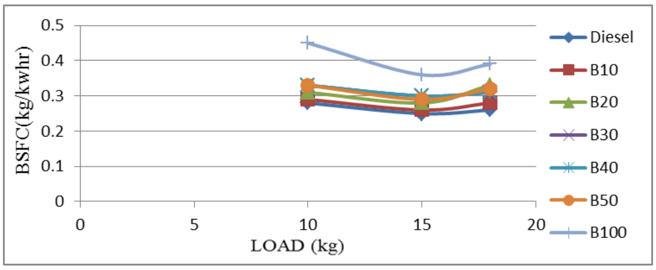


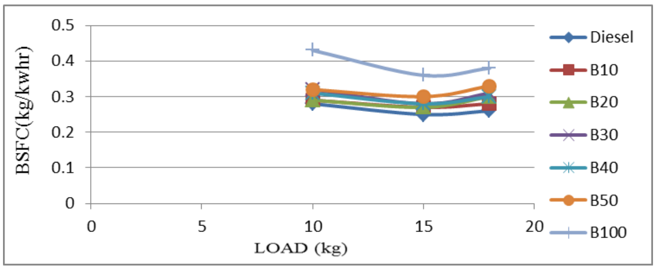
Graph 4 Variation of BTE with Load for Thumba CR 17



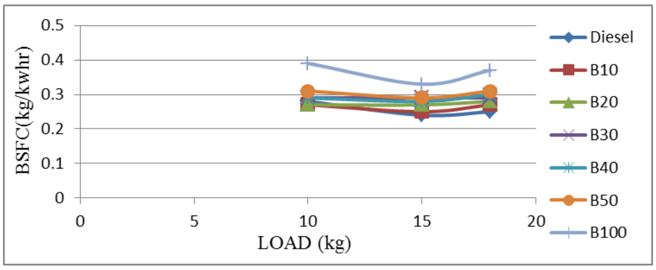
Graph 5 Variation of BTE with Load for Thumba CR 18



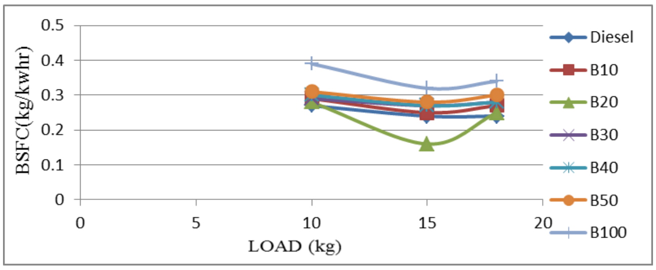
Graph 6 Variation of BSFC with Load for Thumba CR 14



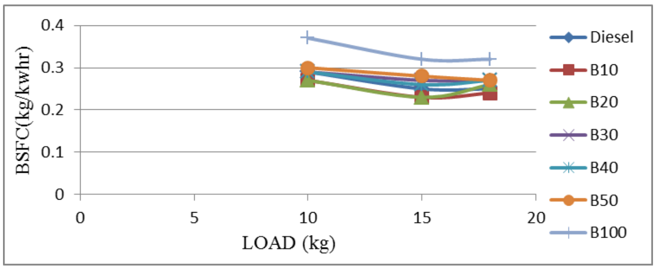
Graph 7 Variation of BSFC with Load for Thumba CR 15



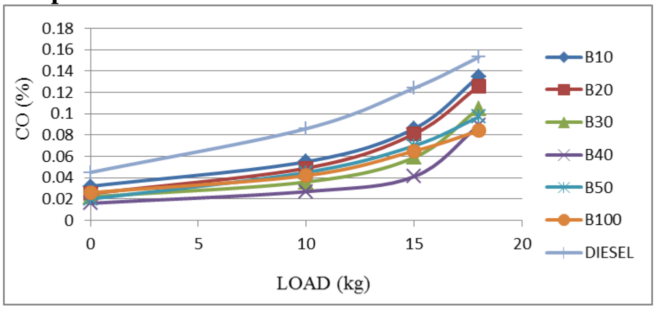
Graph 8 Variation of BSFC with Load for Thumba CR 16



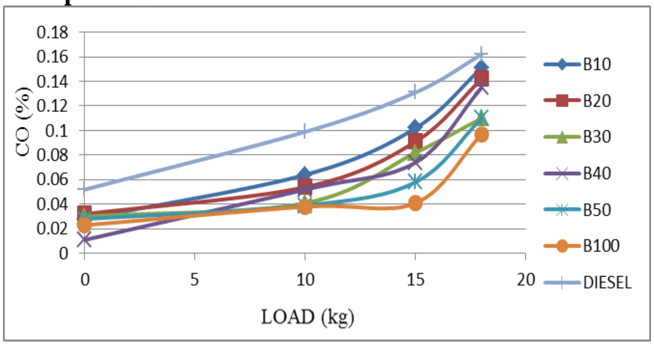
Graph 9 Variation of BSFC with Load for Thumba CR 17



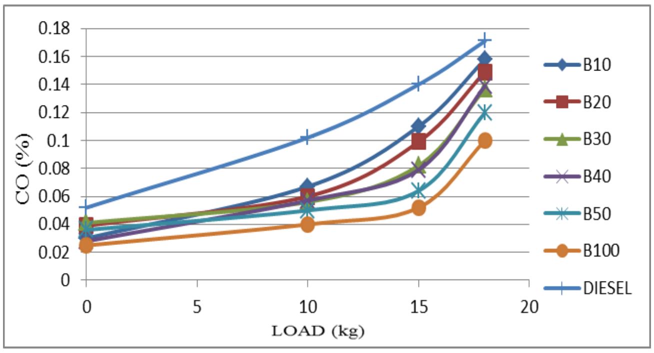
Graph 10 Variation of BSFC with Load for Thumba CR 18



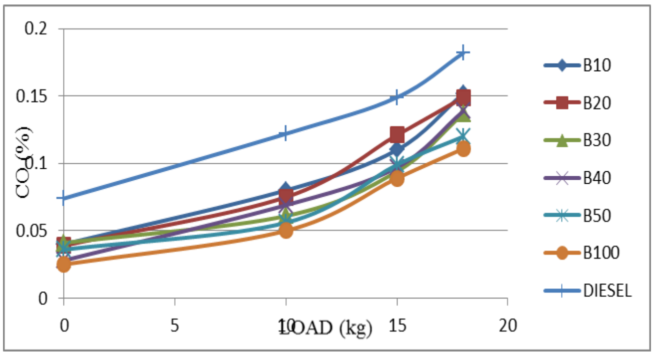
Graph 11 Variation of CO with Load for Thumba CR 14



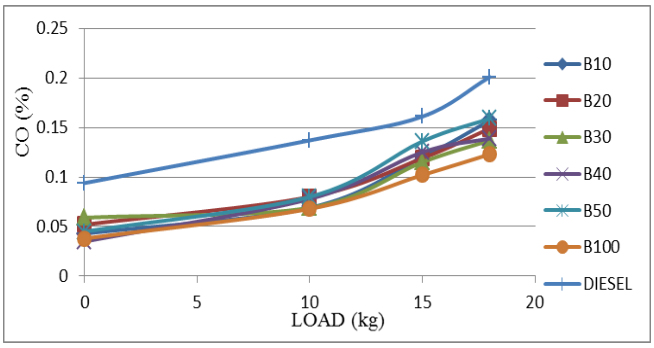
Graph 12 Variation of CO with Load for Thumba CR 15



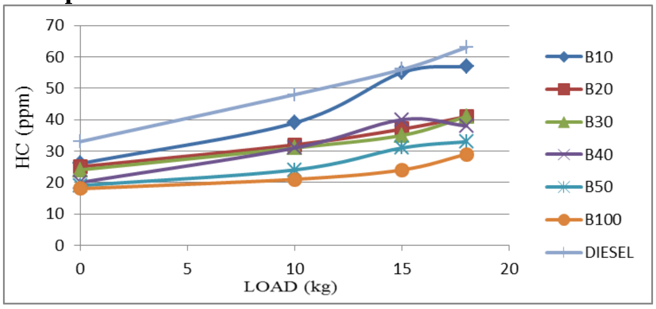
Graph 13 Variation of CO with Load for Thumba CR 16



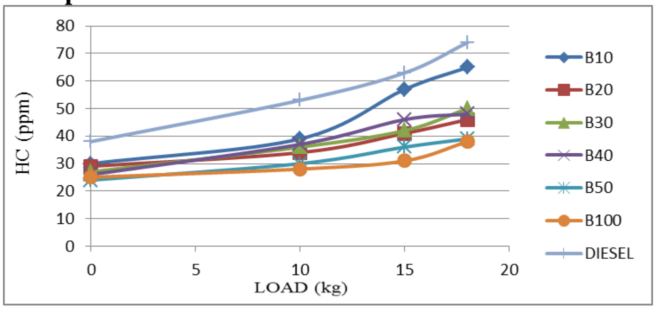
Graph 14 Variation of CO with Load for Thumba CR 17



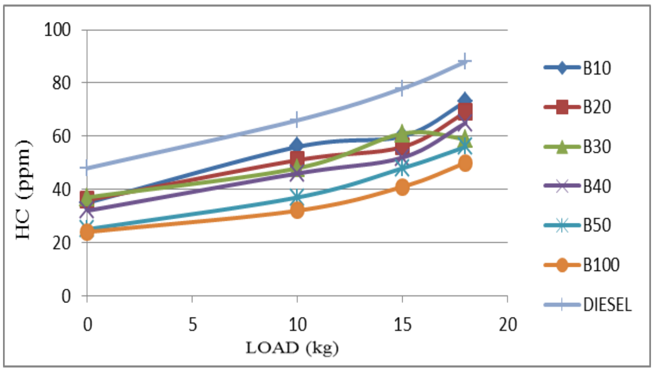
Graph 15 Variation of CO with Load for Thumba CR 18



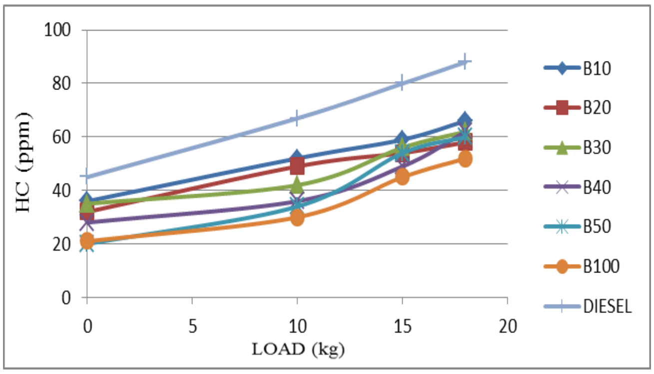
Graph 15 Variation of HC with Load for Thumba CR 14



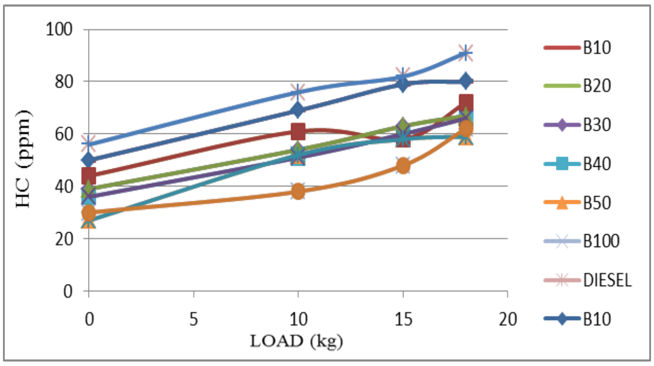
Graph 16 Variation of HC with Load for Thumba CR 15



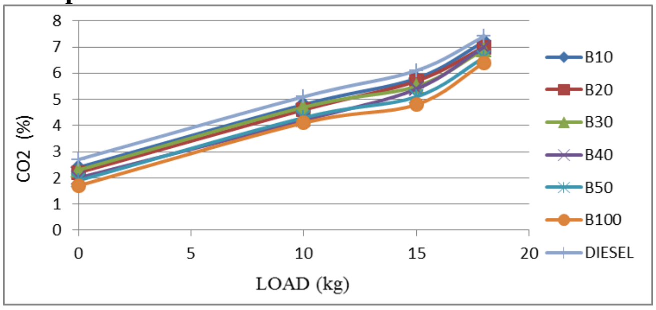
Graph 17 Variation of HC with Load for Thumba CR 16



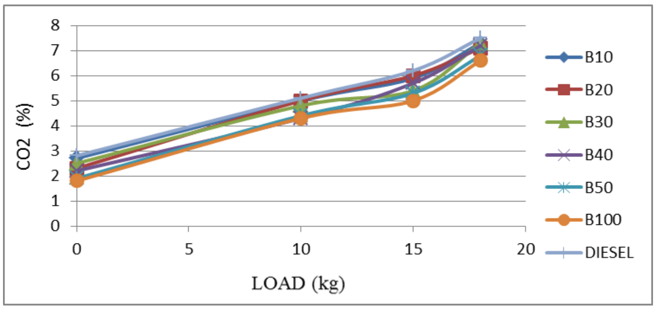
Graph 18 Variation of HC with Load for Thumba CR 17



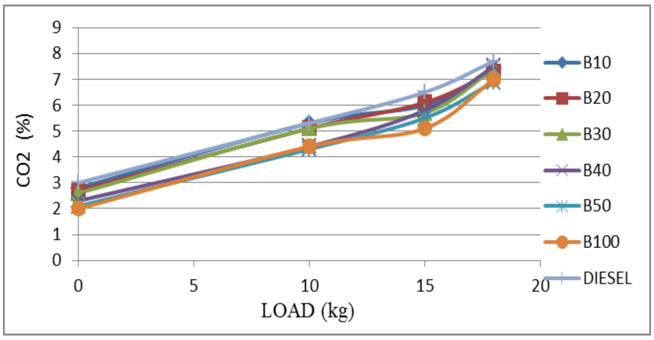
Graph 19 Variation of HC with Load for Thumba CR 18



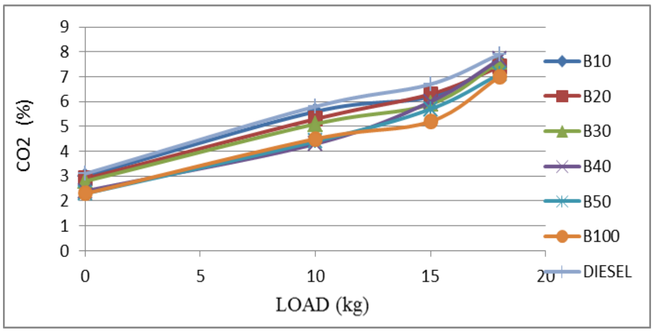
Graph 20 Variation of CO2 with Load for Thumba CR 14



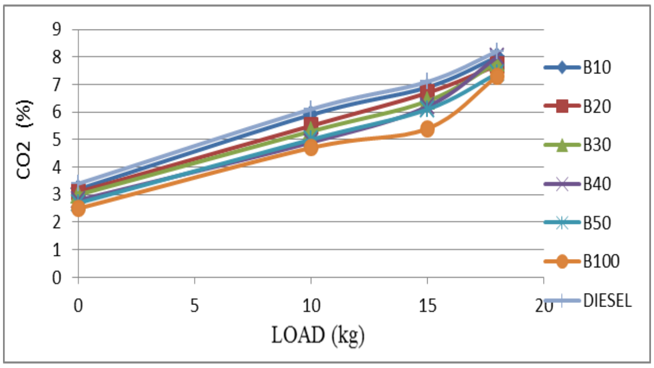
Graph 21 Variation of CO2 with Load for Thumba CR 15



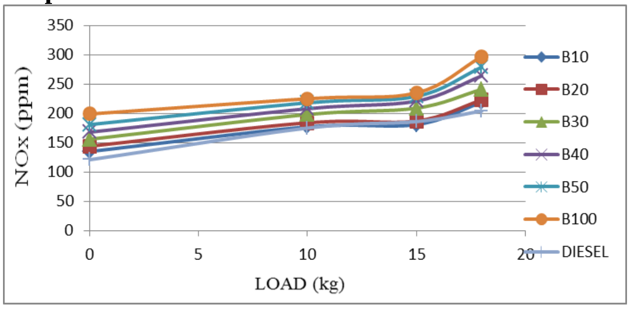
Graph 22 Variation of CO2 with Load for Thumba CR 16



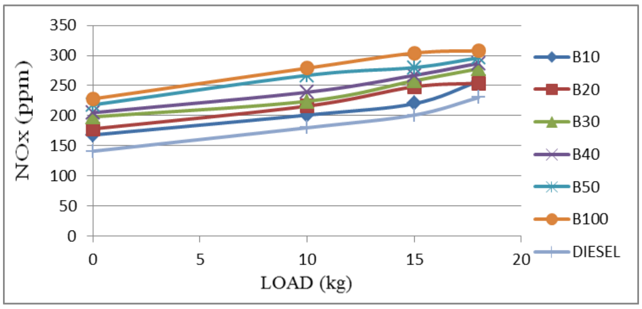
Graph 23 Variation of CO2 with Load for Thumba CR 17



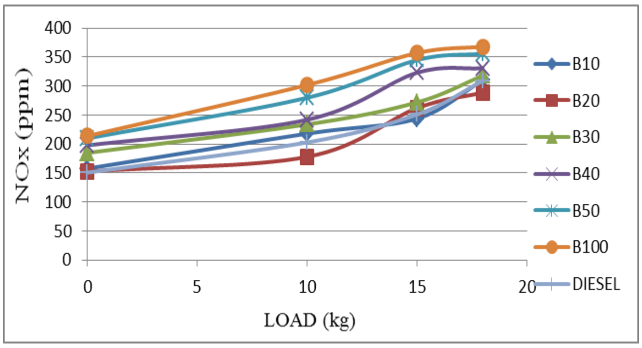
Graph 24 Variation of CO2 with Load for Thumba CR 18



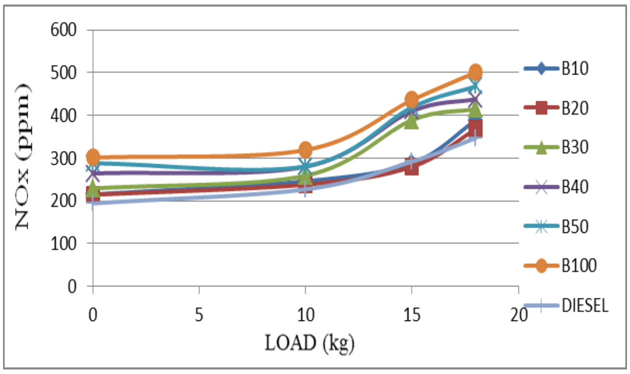
Graph 25 Variation of NOx with Load for Thumba CR 14



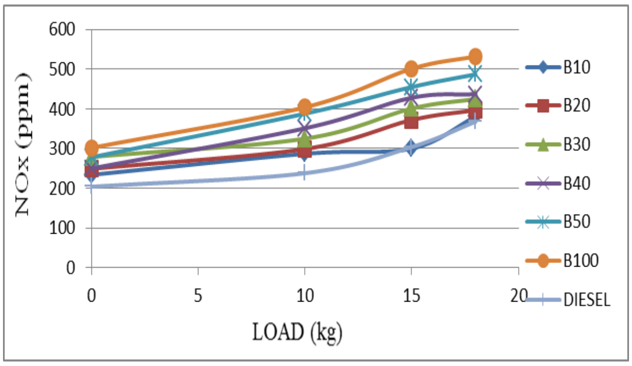
Graph 26 Variation of NOx with Load for Thumba CR 15



Graph 27 Variation of NOx with Load for Thumba CR 16



Graph 28 Variation of NOx with Load for Thumba CR 17



Graph 29 Variation of NOx with Load for Thumba CR 18

IX. CONCLUSION

The main objective of the present investigation was to evaluate the suitability of Thumba biodiesel blend in terms of engine performance and emissions. The performance tests were conducted with diesel, and blends of Thumba at different compression ratios. From the experimental results obtained, Thumba oil blends are found to be a promising alternative fuel for compression ignition engines. At CR 18 BTE and BSFC of Thumba B10, B20 and BP of Thumba B40 showed better performance. The emissions such as CO, HC, CO2 of B100 of Thumba biodiesel showed less emission percentage/ppm , and for NOx emissions of B10 and B20 of Thumba biodiesel showed less emission ppm. Compression ratios and load increases the performance of all blends of Thumba biodiesel showed better performance .At CR 18 BTE,BSFC and BP of all blends of Thumba biodiesel showed better performance than other compression ratios .From engine test results, it has been established that Thumba biodiesel can be substituted for existing diesel in CI engine without any major modifications

1. BTE: - At CR 18 BTE of Thumba B10 (36.31%) showed better performance than all other blends of Thumba biodiesel and pure diesel fuel (33.27%).
2. BSFC:-At CR 18 BSFC of Thumba B10, B20 (0.23 kg/kwhr) showed better performance than all other blends of Thumba biodiesel and pure diesel fuel (0.25 kg/kwhr).
3. BP:-At CR18 BP of Thumba B40 (5.15 kw) showed better performance than all other blends of Thumba biodiesel and the pure diesel (5.07 kw).
4. HC:-Thumba B50 showed better emission performance of HC at all compression ratios than B10, B20, B30, B40 blends of Thumba biodiesel.
5. CO:-Thumba B40 showed better emission performance of CO at CR 14 and for other compression ratios Thumba B100 Showed better emission performance.
6. CO2:- Thumba B100 showed better emission performance of CO2 than other blends of Thumba biodiesel at all compression ratios.
7. NOx:-As load and compression ratio increased ppm of NOx coming from exhaust increased. For all the compression ratios ppm of NOx coming from pure diesel was less than all other blends of Thumba biodiesel. At CR 18 ThumbaB20 Showed better emission than other blends of Thumba biodiesel.

X. ACKNOWLEDGEMENT

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REFERENCES

1. K. Pramanik. "Properties and use of Jatropha curcas oil and diesel fuel blends in C.I engines", Journal of Renewable Energy, 239-248, (2003).
2. F.K.Forson, E.K Oduro, E.Hammond-Donkoh, "Performance of jatropha oil blends in a diesel engine", Journal of Renewable Energy, 1135-1145, (2004).
3. J.Narayana Reddy, A. Ramesh "Parametric studies for improving the performance of Jatropha oil-fuelled compression ignition engine", Journal of Renewable Energy, 1994-2016, (2006).
4. H.Reheman, S.V.Ghadge "Performance of diesel engine with biodiesel at varying compression ratio and ignition timing", Fuel, Volume 87, Issue 12, 2659-2666, (2008).
5. Jehad A. A. Yamin, Nina Sakhnin, Ahmed Sakhrieh, M Hamdan "Performance of C.I. engines using biodiesel as fuel", GCREEDER 2009, Amman-Jordan, (2009)
6. GVNSR Ratnakara Rao, V. Ramachandra Raju and M. Muralidhara Rao "Optimising the compression ratio of diesel fuelled CI engine", ARPN Journal of Engineering and Applied Sciences, APRIL 2008
7. Indraj Singh and Vikas Rastogi "Performance Analysis of a Modified 4-Stroke Engine Using Biodiesel Fuel for Irrigation Purpose", International Journal of Applied Environmental Sciences (2009), 229–242.
8. Amit Pal, S S Kacggwaha, S. Maji and M K G Bahu, "Thumba (Citrullus Colocyntis) seed oil: A sustainable source of renewable energy for biodiesel production "Journal of scientific and industrial research" , Vol 69, May 2010.
9. T. Elango1, T. Senthil kumar "Performance and emission characteristics of CI engine fuelled with non edible vegetable oil and diesel blends", Journal of Engineering Science and Technology, Vol. 6, No. 2 , 240 – 250, (2011) .
10. A.M. Liaquat, M.A. Kalam, H.H. Masjuki, M.H. Jayed "Engine Performance and Emissions Analysis using "Envo Diesel" and Coconut Biodiesel Blended Fuel as Alternative Fuels", 2nd International Conference on Environmental Science and Technology, Vol.6, 2011.
11. Shiv Lal, V. K. Gorana1, N. L. Panwar "A Comparative Study of Thumba Seed Bio Diesel", Journal of Environmental Protection, Vol 2, 454-459, 2011.
12. K. Kalyani Radha, S. Naga Sarada, K. Rajagopal and E.L. Nagesh"Performance and emission characteristics of CI engine operated on vegetable oils as alternate fuels", International Journal of Automotive and Mechanical Engineering (IJAME), Vol 4, 414-427, July-December 2011.
13. H. M. Dharmadhikari1, Puli Ravi kumar ,S. Srinivasa Rao "Performance and emissions of CI engine using blends of biodiesel and diesel at different injection pressures",International Journal of Applied Research in Mechanical Engineering (IJARME), Vol 2, Issue 2, 2012.
14. Suvendu Mohanty, Dr. Om prakash "Analysis Of Exhaust Emission Of Internal Combustion Engine Using Biodiesel Blend",International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 5, May 2013.
15. Sivaramakrishnan Kaliamoorthy, and Ravikumar Paramasivam" Investigation on performance and emissions of a biodiesel engine through optimization techniques", Vol 17, No 1, 179-193, 2013.
16. Mekalilie Benjamin Bol, T. K. Bhattacharya and H. I. Mohammed "Studies on compatible fuel properties of soybean ethyl ester and its blends with diesel for fuel use in compression ignition engines".