

Study of Citrullus Biodiesel Blends on Emission and Performance Characterization of IC Engine

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ABSTRACT: This study explores the emission of different pollutants form by using different blends in IC engine. Biodiesel synthesized from Citrullus colocynthis schard by applying homogeneous catalyst, sodium methoxide and investigate the synthesized citrullus methyle ester for performance and emission of engine. Further the same biodiesel was preceded for emission analysis on single cylinder IC engine with various blending ratios as well as load. Blends (i.e. mixture of biodiesel + fossil fuel) of B00% (i.e. diesel fuel) and Citrullus methyl esters like TB10%, TB20%, TB30%, TB40%, TB50% were prepared at 40°C. The emission parameters like Carbon dioxide (CO₂), Carbon monoxide (CO), Hydrocarbon (HC) etc. and performance parameters like Brake specific fuel consumption (BSFC), and Brake thermal efficiency (BTE) and Brake power were studied and compared with fossil fuel. Result showed that among all methyl ester blends of citrullus, CB20% blend shows lower emissions as well as performance as assimilated with running diesel fuel at all load.

KEYWORDS: Biodiesel, transesterification, engine performance, emissions.

I. INTRODUCTION

In present world fossil fuels are one of the major sources of energy. They have a great utility because of easy usage, availability, cost effectiveness, production of large amount of energy, stability and transportation ease. But due to huge increase in numbers of automobile companies, the demand of fossil fuels also increased. This results into depletion of fossil fuel reservoirs day by day as they are non renewable in nature. We can easily estimate that it will not last after few decades. Also large usage of fossil fuels is not only injurious to health but also hazardous to environment. When they burn they release harmful emissions like carbon dioxide (CO₂), carbon monoxide (CO), nitrogen oxides (NO_x) and unburned hydrocarbons, greenhouse gases which are the main aspects of global warming. Rise in temperature of earth have resulted in melting of polar ice, rise in sea level and mainly acid rains.

The above reasons have lead us to search the alternative fuels which are environment friendly, health friendly, widely available and cost efficient which can work in existing engines with or without minor modification. Different alternate fuels like wind energy, solar energy, geothermal energy, energy from biomass etc are under focus nowadays. But among all these biodiesel seems to be more efficient due to biodegradability, less toxic emissions, easy handling. India is a country where vast vegetation and land availability is there so vegetable oils have come up with promising source of fuel. Many edible and non edible vegetable oils have been investigated in compression ignition engine by fuel modification or engine modification such as sunflower, peanut, olive, soya bean, jathropa, Castrol, pongamia pinnata, cotton seed etc. The vegetable oils have very high density and viscosity, so we have used the methyl ester of the oil to overcome these problems. Their use in form of methyl esters in non modified engines has given encouraging results. With the use of biodiesel it is essential for us to know performance and emission characterization for different proportions of blends, ignition pressure and compression ratio.

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Authors M. Nasarullah , K. Raja Gopal¹ investigate the performance and emission characteristics of a direct injection (DI) 4 stroke single cylinder compression ignition engine of 3.7 KW power,1500 RPM when fuelled with methyl ester of jatropha oil. The experimental results show that the maximum brake thermal efficiency was obtained with 20% Ethanol-2% THF blended with MEJO when compared with pure MEJO and methyl ester of jatropha oil blends. S.M. Palash, M.A. Kalam, H.H. Masjuki, B.M. Masum, A. Sanjid² have compared the engine performance and emission results of biodiesel produced from Jatropha oil when applied in different proportions in multi cylinder diesel engine. Results revealed that biodiesel blends produce less CO (up to 52.6%) and lower HC (up to 48%) with an increase in emission of NO (up to 11.82%). Bobade S.N., Kumbhar R.R. and Khyade V.B.³ have done transesterification of jatropha curcas oil which gives 83% of methyl ester and 17% of glycerol using molar ratio 6:1 (methyl alcohol to oil) and 0.5wt % of sodium hydroxide at 65°C for 90 minutes and allowed to settle overnight. Properties of jatropha biodiesel like density, kinematic viscosity, flash point, fire point were calculated as 0.93292gm/cc, 55mm²/s, 180°C, 256°C respectively. Study suggests that the jatropha oils can be used as a source of triglycerides in the manufacture of biodiesel by transesterification reaction. Y.H. Basavarajappa , N.R. Banapurmath⁴ presents paper which studies the effects of ethanol addition and Exhaust Gas Recirculation (EGR) and on performance, combustion and emissions of compressed natural gas (CNG) dual fuelled with Honge oil methyl esters (HOME) and Jatropha methyl ester (JOME) in a dual-fuel engine. Bobade S.N. and Khyade V.B.⁵ have studied transesterification of karanja oil which shows have checked the feasibility of Karanja oil for the production of biodiesel optimization of different parameters for high yield /conversion of Karanja oil to biodiesel. Sushma. S, Dr. R. Suresh, Yathish K V⁶ have observed that a complete substitution of petro diesel by bio fuel is impossible with the use of edible and non edible oil, hence in the present study dairy waste scum oil and karanja oil (in equal quantities) is used to produce hybrid oil biodiesel by transesterification process using sodium hydroxide as catalyst.

Supriya B. Chavan,^a Rajendra R. Kumbhar,^b D. Madhu,^c Bhaskar Singh^d and Yogesh C. Sharma^e have prepared biodiesel from Jatropha curcas oil using waste eggshell. High purity calcium oxide (CaO) was prepared from eggshell and used as a catalyst for the production of biodiesel. Non-edible oil, Jatropha curcas was used as a feedstock for the synthesis of biodiesel. High purity calcium oxide (CaO) was obtained when the eggshell was subjected to calcination at 900⁰ C for 2.5 h. Pure biodiesel was obtained in high yield by taking into account various parameters such as a proper methanol to oil molar ratio, reaction temperature and reaction time. Reusability of the catalyst was observed and the catalyst worked efficiently up to six times without significant loss of activity. Physical and chemical properties of biodiesel such as density, kinematic viscosity, cloud point, etc. were studied.

Supriya B. Chavan, Rajendra Rayappa Kumbhar, Ashutosh Kumar, and Yogesh C. Sharma⁸ Studied Biodiesel Blends on Emission and Performance Characterization of a Variable Compression Ratio Engine. They studied the emission of different pollutants using different blends in a variable compression ratio (VCR) engine. Biodiesel synthesized from Jatropha oil using a heterogeneous catalyst was investigated for emission analysis on a single-cylinder VCR engine with various blending ratios as well as load. Blends (biodiesel + diesel) of different concentration were prepared at 40⁰ c. Emission parameters, such as nitrogen oxides (NO_x), carbon monoxide (CO), and hydrocarbon (HC), were studied and compared to diesel fuel.

Chavan S.B. , Kumbhar R.R. and Deshmukh R.B.⁹ have proved that Calophyllum Inophyllum Linn (“honne”) Oil is the best source as a raw material for biodiesel production as it is an evergreen tree and grows along the coastal area. The study is focused on the collection of seeds and oil extraction then production of biodiesel with molar ratio 8:1, KOH were 1.2wt%, temperature 65⁰ c, reaction time 90minutes and testing of parameters as per ASTM 6751 standards. The physical properties like acid value, density, Calorific value, Flash point, Fire point and Moisture, Viscosity shows of calophyllum methyl esters were calculated. The physico-chemical parameters showed that Calophyllum may works as a sustainable feedstock for biodiesel production that is equivalent to fossil fuel as per ASTM 6751.

Chavan S. B., Kumbhar R. R. and Sharma Y. C.¹⁰ have studied the transesterification of Citrullus colocynthis (Thumba) oil and have proved that it is the best source as a raw material oil for biodiesel production as it is a climber and grows wild in western part of Rajasthan. The study is focused on the collection of seeds and oil extraction then proceed for

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biodiesel production with molar ratio 8:1, KOH were 0.75wt%, temperature 65°C, reaction time 90 minutes were used and testing of parameters as per ASTM 6751 standards. The physical properties like acid value, density, Calorific value, Flash point, Fire point and Moisture, Viscosity of Thumba methyl ester (TME) were calculated.

Chavan Supriya Baburao, R. Rohith Renish, Shinde Chandrakant Anna, Kumbhar Rajendra Rayappa¹¹ have used Ecofriendly Heterogeneous Catalyst (CaO) for Synthesis of Biodiesel and then studied its Characterization on VCR Engine. Waste crab shells after calcination have been used as a nonconventional heterogeneous catalyst for biodiesel synthesis from pongamia oil. Crab shell was calcined in muffle furnace at 1100 °C for 2hrs. The calcined catalyst was characterized on X-ray diffraction (XRD), Fourier transform infrared (FTIR) spectroscopy and Scanning electron microscopy (SEM). The highest yield is obtained. Then blends of different concentration were prepared and its performance and emissions are compared against pure diesel. It is found that an ecofriendly, heterogeneous catalyst made from raw egg shell can be a low cost solution for biodiesel synthesis. Also emissions like CO, CO₂ and HC are lowered as compared with diesel.

Bobade S.N., Kumbhar R.R. and Khyade V.B.¹² have prepared of Methyl Ester (Biodiesel) from *Jatropha Curcas* Linn Oil. Transesterification of *jatropha curcas* oil is done, which gives >83% of methyl ester and >17% of glycerol using molar ratio 6:1(methyl alcohol to oil) and 0.5wt % of sodium hydroxide at 65°C for 90 minutes and allowed to settle overnight. As per ASTM 6751(American Standards For Testing and Material) the properties like density, viscosity, flash point, cloud point and pour point have been carried out at Indian Biodiesel Corporation, Baramati for accessing the fuel quality of *Jatropha* oil methyl ester. Thus this study suggests that the *jatropha* oils can be used as a source of triglycerides in the manufacture of biodiesel by transesterification reaction. The biodiesel from refined vegetable oils meets the Indian requirements of high speed diesel oil.

Above literature survey encourage us to pursue our work.

The present work investigates the suitability of Thumba biodiesel (*Citrullus colocynthis*) as an alternative fuel and calculating its performance and emission characterization on IC engine using some catalyst to increase the speed of the process.

II. MATERIAL AND METHODS

1. Fuel Production And Properties

There is a best source as a raw material that is *Citrullus Colocynthis* (Thumba) oil for biodiesel production. It is a climber and grows wild in western part of Rajasthan. The average yield is about 2500-3500 kg of seeds/ ha. with minimum inputs. Seeds contains 12-20% of golden yellow- brown oil. De oiled cake has a great importance in organic fertilizer industry.

The biodiesel fuel used (methyl ester) is obtained from Thumba oil by transesterification process. It is the process by which fatty acid is converted into its corresponding ester.

1000 ml of Thumba oil was measured and poured into a 2000 ml three necked round bottom flask. This oil was heated upto 60°C. In 250ml beaker a solution of potassium methoxide was prepared using 0.5, 0.75 and 1.25 wt.% potassium hydroxide pellet with the molar ratio 1:6, 1:8 and 1:10 of oil to methanol were studied. The solution was stirred until the potassium hydroxide pellet was completely dissolved(the mixture was called potassium methoxide solution). The solution was then heated upto 60°C and slowly poured into preheated oil. The mixture was stirred (650rpm) vigorously for 10, 20, 30, 40, 50, 60, 70, 80 and 90 min.. Finally FFA was checked and mixture was allowed to settle for 24 hours in a separating funnel. Thereafter, upper layer biodiesel was decanted into a separate beaker while the lower layer which comprised glycerol and soap was collected from the bottom of separating funnel. To remove any excess glycerol and soap from the biodiesel, hot water was used to wash it then allowed it to remain in separating funnel until clear water was seen below the biodiesel in the separating funnel. The PH of biodiesel was then tested. The washed biodiesel

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sample was then dried by placing it on a hot plate and excess water still in the biodiesel removed. Finally thumba methyl ester is obtained and further blended with diesel fuel to obtain different compositions.

The biodiesel is blended with the diesel fuel in different concentration. Biodiesel is blended with diesel by volume as B10 (10% Thumba biodiesel & 90% diesel fuel), B20 (20% Thumba biodiesel & 80% diesel fuel), B30 (30% Thumba biodiesel & 70% diesel fuel), B 40(40% tumba biodiesel & 60% diesel fuel) and B100 (100 % thumba biodiesel & 0% diesel fuel) then these samples were proceed for their property testing. Table 1. Shows the properties for each blends and their comparison with diesel fuel. For every blend the value of density and calorific value changes as the concentration of blend changes. The density of thumba biodiesel and diesel fuel is different. When these two blend together the density will slightly increased than the density of diesel fuel. Same way calorific value will also change.

Table. 1 : Analysis of Thumba Biodiesel and its Blends

Sr.	Properties	Reference		Diesel	Thumba oil biodiesel blends				
		Unit	Limit	B100%	TB10%	TB20%	TB30%	TB40%	TB100%
1.	Density	Gm/cc	0.800-0.900	0.834	0.836	0.839	0.841	0.844	0.872
2.	Viscosity	Cst	-	2.700	-	-	-	-	5.10
3.	Calorific Value	Cal/gm	-	42.50	42.00	41.59	41.05	40.60	37.5
4.	Cetane no.	-	41-55	47.0	-	-	-	-	41.5
5.	Flash point	^o C	-	67.00	-	-	-	-	164
6.	Fire point	^o C	-	74.00	-	-	-	-	171
7.	Moisture	%	-	Nil	Nil	Nil	Nil	Nil	Nil

2. Experimental set-up

Experimental investigation is carried out on a typical single cylinder, 4 stroke diesel engine. With rope brake diameter as shown in fig (a). Exhaust gas temperature is used for checking emissions. Exhaust gas emissions such as CO, CO₂, Unburned HC and excess air ratio are measured. Smoke meter is used to measure smoke capacity. Engine is started under no load condition and then warmed up at the rated speed of 1500 rpm and all the readings are taken under steady state conditions. Technical details of the engine are given in Table. 2.2.

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(a)

Table 2 : Technical Specification of diesel engine

1.	Rated Power Output	5 HP
2.	Rated Engine Speed	1500 rpm
3.	Stroke Length	95 mm
4.	Bore Diameter	87.5 mm
5.	Calorific Value of Fuel	43890 KJ/Kg k
6.	Density of Fuel	855kg/m ³
7.	Jacket Cooling Water Flow Rate	12 lit/min
8.	Burrete Diameter	12
9.	Orifice Diameter	25

Engine performance parameters such as brake power, efficiency, emissions and smoke capacity are quantified. Engine is run at 1500 rpm and data are collected with respect to combustion, emission and performance parameters at various loads of 2, 4, 6, 8.

III. RESULT AND DISCUSSION

Diesel engine performance, emission and combustion characteristics are analyzed for all blends of TB10%, TB20%, TB30%, TB40% and TB100% fuels and compared with petroleum diesel. All the performance and emission results are presented and discussed in this section.

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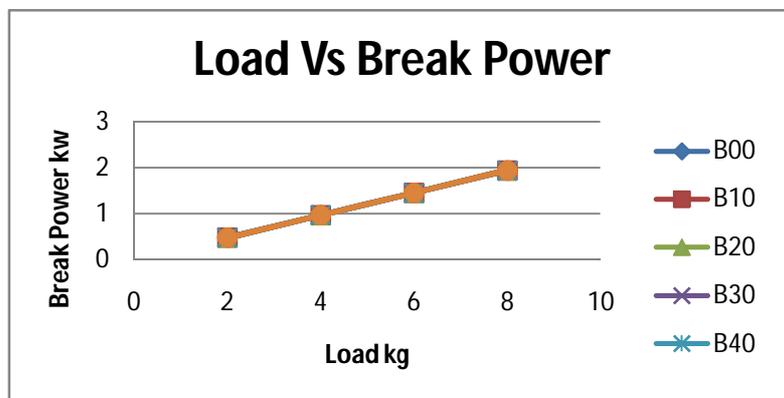
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Performance characterization :

1. Brake Power :

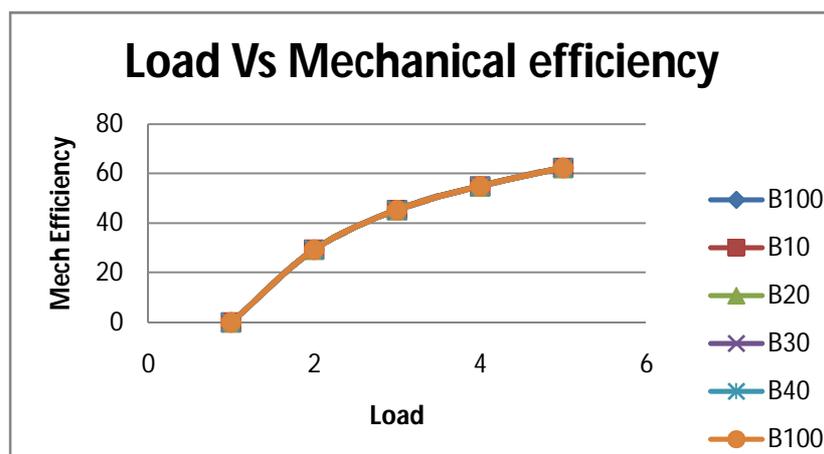
The main purpose of running an engine is Mechanical Power. Power is defined as the rate of doing work and is equal to the product of force and the linear velocity or the product of torque and the angular velocity. Thus the measurement of power involves the measurement of forces as well as speed. Here we have calculated brake power for each blends and compared with pure diesel fuel. The graphical representation is show in fig. (b)



(b)

2. Mechanical Efficiency (η_{mech})

Mechanical efficiency measures the effectiveness of a machine. It is defined as the ration of break power to indicated power. We have plotted graph of Mechanical Efficiency for each blends at different loads. And we have observed that as the load increases the mechanical efficiency also increases. Graphical representation of load vs mech efficiency is shown in fig. (c)



(c)

3. Break Thermal Efficiency

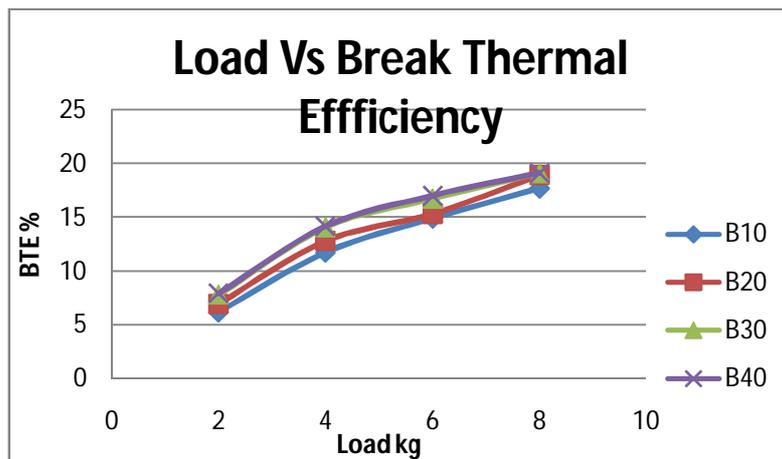
Thermal efficiency of an engine is defined as the ratio of the output to that of the chemical energy input in the form of fuel supply. If different fuels are to be compared for the same engine, brake thermal efficiency is the most suitable

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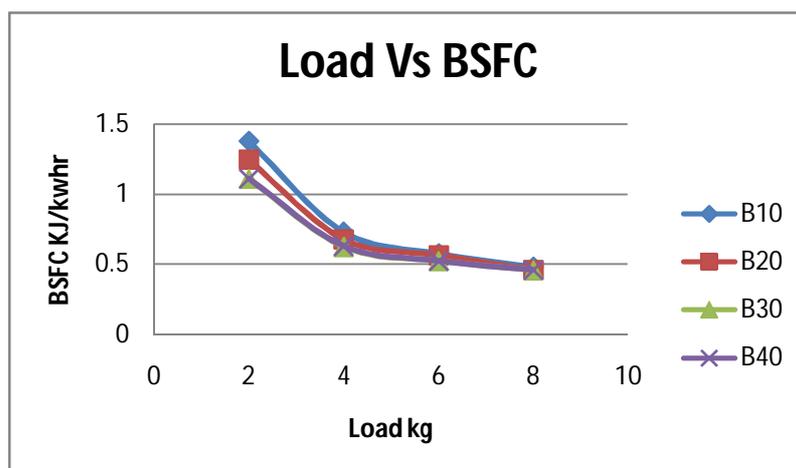
parameter instead of specific fuel consumption. Fig. (d) shows the BTE of all biodiesel blends and petroleum diesel under different loading conditions. The maximum brake thermal efficiencies at load 8 for diesel, TB10%, TB20%, TB30%, TB40% and TB100% are calculated as 17.86%, 18.9%, 19.1%, 19.11% etc.



(d)

4. Break Specific Fuel Consumption (BSFC)

Specific fuel consumption is defined as the amount of fuel consumed per unit of power developed per hour. It is a clear indication of efficiency with which the engine develops power from fuel. The variation in Break Specific Fuel Consumption against the load is shown in fig (e) We can observe that the increasing power results in decreasing consumption of fuel.



(e)

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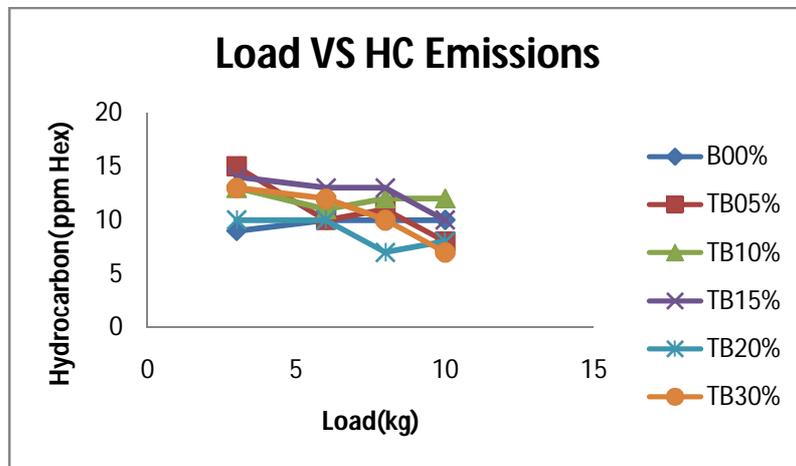
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Emission Characteristics :

1. Unburned Hydrocarbons (UBHC)

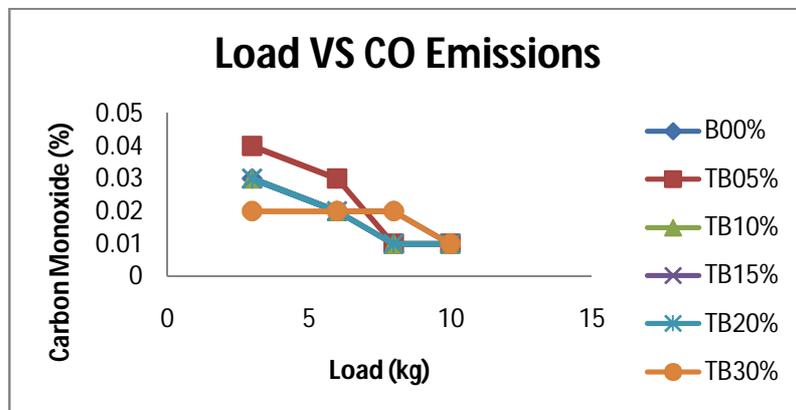
Unburned hydrocarbon (UBHC) pollutants are formed when the fuel is not completely burned. UBHC is one of the important parameters for determining the emission behavior of diesel engine. Comparison of UBHC of all the Thumba biodiesel blends and diesel at various load is shown in Fig. (f). It is shown that the variation in UBHC decreases with the influence of Thumba biodiesel percentage in bio-diesel blends. It is also confirmed that thumba biodiesel emission are reduced to much extent of UBHC emissions when compared to base line diesel at full load condition.



(f)

2. Carbon monoxide (CO)

It is the most common type of fatal air poisoning in many countries. It is colorless, odorless and tasteless, but highly toxic gas. Fig. (g) shows the variation in carbon monoxide of all the tested fuels with respect to load. It is learned that the variation in CO emissions for all biodiesel blends and diesel is fairly small. It is also identified that CO concentration of Thumba biodiesel emission is lower than conventional diesel at rated load. This may be due to the oxygen content and less C/H ratio of biodiesel that causes complete combustion. However, it is revealed that the decreasing trend of CO emission does not rely on biodiesel percentage in the blends.



(g)

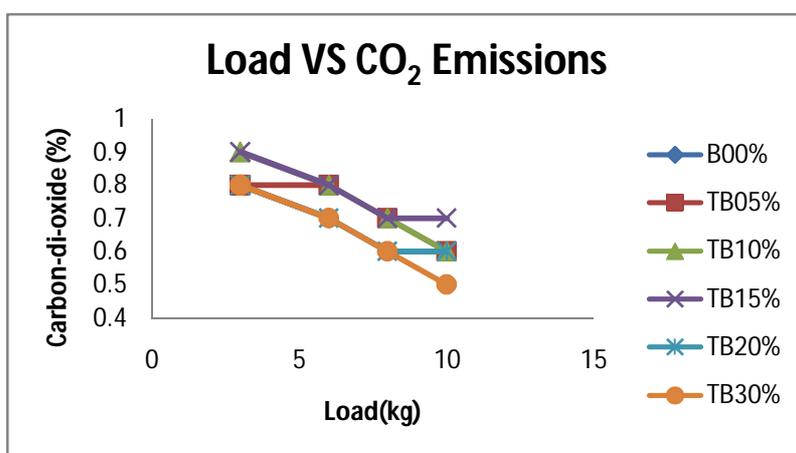
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3. CO₂ Emission

CO₂ causes rise in sea level, reduction of ozone layer, global warming and fatal diseases. Fig. (h) shows the variation in carbon dioxide of all the tested fuels with respect to load. It is learned that the variation in CO₂ emissions for all biodiesel blends and diesel is fairly small. It is also identified that CO₂ concentration of Thumba biodiesel emission is lower than conventional diesel at rated load.



(h)

IV. CONCLUSION

From above results it is concluded that Thumba Biodiesel has come up with one of the best alternative sources. It can be used in diesel engine as an alternative fuel or by blending it with diesel fuel and is found to give better performance. It has been found that harmful emissions like CO₂, CO are reduced while Nitrogen Oxides (NO_x) emission is higher than that of diesel fuel.

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