Effect of Algae Biodiesel on Performance, Combustion and Smoke Characteristics of CI Engine

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ABSTRACT:

The aim of this experimental investigation is to compare the performance, combustion and emission characteristics of various blends of algae namely B10, B20, B30, B40, B50 with diesel on a variable compression ratio diesel engine. The experimental results showed that algae can be very good alternative biofuel with blend B20 giving very attractive results. The emission of CO, CO2, and HC are also reduced but NOx emission is increased. Overall Algae biodiesel is very good option and more research can be carried out by varying the compression ratio and also using some additives.

Keywords: Cotton seed oil, Bio-fuel, Engine Performance, Emission

1. INTRODUCTION

Energy is the main source of living now a days. It is basically divided into two main forms which are renewable and non-renewable. Between these two, non-renewable form of energy supplies is mostly used. From study it is found that about 80 percent energy come from non-renewable fossil fuels such as coal, natural gas and petroleum products which cause about 98 percentage of carbon emission as a result of its combustion. This emissions in the atmosphere must be reduced as minimum as possible. The non-renewable sources are depleting day by day and its prices are increasing. Also these petroleum products are not evenly distributed all over the world. We can see that about 63 percent of its total quantity is found in Arabian countries. Due to which they have become a dominant supplier and thus they advantage of this situation by increasing the prices. Hence there is need to develop a alternative renewable energy source. Combustion of diesel and petrol causes pollution and also one day they will be exhausted. So there is need to find an alternative fuel to petrol and diesel which can be then used in IC engine. Thus an important alternative found is biofuels. Biofuels like crop oils, vegetable oils, animal fats, starches from various crops etc are being researched for use in IC engine.

We know that biodiesel was firstly produced from edible crop seeds like sunflower, soyabean, groundnut, rapseed, coconut etc. These are considered as first generation biodiesel feedstock. However use of edible feedstocks was prohibited , as it would cause imbalance in food reserves and cause problems. Later non-edible crop seeds like Jatropa , karanja, mahua , cotton seed oil ,animal fats etc were being use for biofuel production. These are considered as second generation biodiesel feedstocks. They gained considerable importance but they are not sufficient to substitute in transportation system. So recently research has been carried out to use microalgae for biodiesel production. It is considered as third generation biodiesel feedstock. Like other biofuels, Algae also use photosynthesis to convert solar energy into chemical energy. They store this energy in the form of oils, carbohydrates, and proteins. This oil can be converted to biodiesel. Hence this algae biodiesel is a form of solar energy. Algae take the carbon dioxide from the environment and sunlight from the sun and by photosynthesis converts this solar energy in chemical energy which can be harnessed to produce biodiesel with considerable calorific value. Also microalgae have higher biomass production rate compared to other crops. It doesnot require cultivable land for its growth. It can be cultivated on barren land or saline water land. From studies it has been found that an alga has considerable lipid content in it which can be harnessed to production biodiesel from it. Many different species of algae have been found out and still research has been going on to find out which one is most suitable for biodiesel production and has maximum oil content. These species include Spirulina, Chlorella, Spirogyra pond water algae etc. We have chosen Spirulina species of algae for our research work.

In this article the importance of using algae as a biodiesel is discussed. Algae is a fast growing crop which can be grown on any land which may be sewage or saline. It does not require any fertile land like other crops. It is a fast growing, high lipid content crop which uses basically sunlight and carbon dioxide from the atmosphere for its growth. The growth and productivity depends on the algae cultivation culture. Author has also discussed various species of algae, there growth methods, biodiesel production techniques, various properties ,various methods of oil extraction ,cost parameters etc. Using of algae for biodiesel production is very advantageous as it has more oil production compared to other feed stocks also key tool for reducing greenhouse gas emissions [1]. The potential of microalgae for biodiesel production was studied in this investigation. With the increase in the demand of alternative fuel, biodiesel production is gaining importance. Also importance of reducing polluting gases produced by combustion in IC engine must be considered. In this article various generations of biodiesel is told with microalgae being the third generation of biodiesel feed stock. Algae has high biomass production efficiency and high photosynthetic efficiency. Here the study is dealt with three different species namely Spirulina, Chlorella and pond water algae to understand and analyse properties algae biomass, algae oil and algae biodiesel. Here the growth patterns of various species is studied deeply , also the effect of different solvent addition on biodiesel production is done and the best one is chosen. Later various important fuel properties like density, viscosity, specific gravity, flash point, pour point, calorific value etc are studied and compared. After all the analysis the best species is stated [2]. This paper basically represents the analysis of impact of use biodiesel produced from of micro algae to power diesel engines. Biofuels which is produced from algae has less environmental impact than other crops which may affect the food chain. Algae requires less land as compared to other crops for its cultivation. The lipid content is about 8% to 40% of biomass which mainly depends on cultivation culture condition. After conducting the test in VCR engine it was found that there is some decrease in the power and the torque produced by biodiesel fulled engine compared to diesel fuelled engine. There was increase in NOx emissions but some pollutants were reduced. Also there as some increase in combustion temperature. Blend B20 was most suitable blend for powering engine with various advantages. As less research has been done in this field more study must be done and this area must be exploited[3]. This study aims to investigate the use of hydrogen and hydroxy gas in CI engine which is being fuelled by microalgae biodiesel. With the increasing prices of petrol and diesel Algae biodiesel can be used as an promising alternative for use in IC engine. It was found that there is decrease in the carbon monoxide production but increase NOx and Carbon dioxide production from engine. Also due to use of algae biodiesel there decrease in torque and power developed. Thus to compensate the decrease in torque and power hydrogen and hydroxyl gas is used along with algae biodiesel. Hydrogen is a promising alternative fuel but it has high self ignition temperature. Thus it can be used as a secondary fuel along with algae biodiesel to initiate the combustion in engine and good results can be obtained[4]. In this article B20 blend of Spirulina microalgae biodiesel was used to study its performance, combustion and emission characteristics on a direct injection diesel engine. Various parameters like specific fuel consumption, thermal efficiency, exhaust gas temperature, heat release rate, particulate matter, oxides of nitrogen, smoke etc were studied at variable speed. Also the experimental results were validated by numerical results by author. It was found that spirulina microalgae biodiesel can be used in diesel engines with some advantages and disadvantages. It was found that thermal efficiency was reduced to about 1.2 % and fuel consumption was increased by 5.08% compared to diesel as fuel. There was reduction in PM, NOx, smoke but increase in carbon dioxide. It was concluded with different emulsion blends must be tested inn diesel engine and algae can be used as an alternative to diesel with some modifications [5]. In this article the authors made a very good effort to systematically study and review various published research work done in number of biodiesel fuels from various sources and provide a single paper with all this information. This paper provides us with vast data of analysis of more than 20 biodiesels with the comparison of their performance , combustion and emission characteristics of each biodiesel. We know that diesel engines are more popular in automotive and industrial sector. However as we know how the demand for the fossil fuel is increasing and they are rapidly depleting. The emission for diesel engines are also harmful as they have NOx emissions , SOx emissions and particulate matter. Even most of the countries import diesel ,which effects there economy due to increased prices. Hence biodiesel was found to be the best alternative as it is renewable, biodegradable, no sulphur content etc. More than 350 oil- bearing crops have been identified and reaserch on much more is being carried out. This paper includes analysis of biodiesels like cotton seed, karanja, jatropa, honge, algae oil, mahua oil, turpentine oil etc [6]. This paper reviews about the use of biodiesel as an alternative in the marine engines. Marine industry has a huge impact on goods transportation and travelling. We know that diesel engines are used in Ships. These engines emit a lot of toxic exhaust gases. So there is a need to reduce the amount of harmful gases as well as an alternative fuel for engine must be found. By using biodiesel gases like carbon monoxide, oxides of sulphur, smoke are reduced but NOx gases are increased also the brake specific fuel consumption increased. As marine engines are considered a significant contributor in air pollution there are various state as well as international laws which are implied and are continuously improved. As biodiesel has various advantages like environmental friendly, nontoxic, renewable, easy to use without any modification in engines, lower emission , biodegradable, higher lubricity etc. it has a bright future as a alternative energy sources. It cannot completely fulfill all the demands due to some limitations like fuel stability, cold flow properties, higher production and feedstock cost etc. but can provide a helping hand towards providing the energy balance[7]. In this research work the author has conducted an experimental investigation on diesel engine by using three different biofuels namely, jijoba methyl ester, algae methyl ester and chocolate waste methyl ester and compare the engine roughness and exhaust emissions with that of conventional diesel fuel results. Now a days a lot of research has been carried out on use of biodiesel as an alternative source in diesel engines. This is mainly because of depleting nature, increasing costs, pollution caused by its use etc Here the author has conducted the experiment on a single cylinder diesel engine in two sets. Firstly the load is varied by keeping speed, compression ratio and injection timing constant and later the injection timing is varied by keeping remaining factors constant. The emissions like CO, CO2, NOx, Particulate matter, SOx were measured also engine roughness was also measured The results obtained are compared with that of diesel powered engine[8]. In this work author has conducted an experimental analysis of microalgae diesel blend and microalgae diesel and butanol blend on a diesel engine and measured the performance parameters and emissions coming after combustion. The blends used were diesel 80% and 20 % microalgae fuel, diesel 70% algae 20% and butanol 10%, diesel 60%, algae 20% and butanol 20%. By previous studies it was found that algae and diesel blend when combusted produce less carbon dioxide, CO, particulate matter. But there was increase in NOx emissions. By using butanol along with algae biodiesel although reduces the torque and power but the emissions are considerably reduced. Also it was found that the fuel properties like density, viscosity, cetane number, pour point were comparable to that of diesel fuel. Butanol was found out to be a promising additive to diesel- microalgae biodiesel blends [9]. Many researchers have been carried out by using different biodiesel feedstocks in diesel engine. Using biodiesel has a lot of advantages and can be an alternative to diesel but it also has some disadvantages like increase in NOx emission and brake specific fuel consumption. Thus thus paper reviews about changing the injection parameters like injection timing and injection pressure so that this disadvantages can be handled. We know that injection timing and pressure plays an important role in complete combustion of the diesel in combustion chamber. Thus it also affects the emission gases . In case of biodiesel fueled engines it can be implemted to reduce the harmful emissions. It was found that by advancing the injection timing and increasing the injection pressure reduces carbon mono oxide, particulate matter, haydro carbon, carbon dioxide and also oxides of nitrogen. Thus the emission characteristics can be enhanced to a eco friendly natur[10]. This research work gives us a considerable knowledge about the performance, combustion and emission analysis of diesel engine which is fuelled with algae biodiesel and algae oil. Here the algae species used is chlorella vulgaris. It was found that 28% of algae oil was extracted from the algae biomass and 85% of algae biodiesel was obtained after transestarification process. Algae oil was obtained by solvent extraction process by using n- hexane as solvent and potassium hydroxide and methanol were used during the transesterification process. When fuelled in diesel engine various parameters like brake specific fuel consumption, brake thermal efficiency, smoke opacity, exhaust gas temperature, unburned hydrocarbon emission, CO emission, NO emission were studied. It was concluded that algae biodiesel can be used as an alternative fuel in diesel engine without any modification [11]. Biodiesel is considered as one of the most suitable alternative for the nonrenewable petroleum fuel. In this experiment the author has used Jatropa methyl ester to study the performance, combustion and emission analysis when used in a single cylinder diesel engine. The speed was kept constant and the load and compression ratio were varied. By varying the compression ratio its impact on fuel consumption, emission gases, combustion pressure were studied and the best suitable compression ratio was selected. Main objective was to study the emission gases like CO, HCs, NOx, CO2, SOx, Particulate matter coming from engine when different biodiesel blends were used. It was concluded that various fuel properties of Karanja are comparable to that of diesel and can be used I diesel engine without making any changes in engine. Also a lot of emission were under control [12]. In the present study Linseed oil biodiesel blend is used as an alternative to the diesel in VCR diesel engine and the results obtained are discussed. With the increasing industrialization and transportation there will be shortage of the nonrenewable petroleum products. Also the use of petroleum products leads to harmful pollution of atmosphere. Thus use of biodiesel is chosen to be the best alternative. Here linseed oil is used as biodiesel with 20% blend and the compression ratio is varied at different loads. It was seen that brake thermal efficiency is slightly lower as the calorific value is less than diesel. Brake specific fuel consumption, exhaust gas temperature is higher than that of diesel. Volumetric efficiency of linseed oil biodiesel used is more at all compression ratios and the mechanical efficiency is less than that of diesel [13]. In this study the author has studied the use of Jatropa ethyl ester and it blends with diesel in VCR diesel engine and compared various parameters like performance parameters (brake thermal efficiency, brake specific fuel consumption, mechanical efficiency) and emission parameters (carbon monoxide and NOx) and compared with that of diesel fuelled engine. As there is an increasing need to find an alternative for fossil fuels Jatropa biodiesel is considered as an alternative by author and conducted the experiment. It was found that the brake thermal efficiency of jatropa blend fuelled engine was more than that of diesel at 17.5:1 compression ratio. Brake specific fuel consumption increases with increase in load on engine. Carbon monoxide emission were reduced whereas NOx emission were increased as compared to that of diesel fuel. It was concluded that jatropa ethyl ester with 40 percent blend with diesel can be used as an substitute in diesel engine with optimum results[14]. Here the author has studied the use of Macroalgae derived biofuels and its energy extraction methods. An alga has the potential to be an alternative source of energy for the fossil fuels used in IC engine due to high lipid content. Also it doesnot require and cultivable land and fresh water. It can grow in barren land and saline water also. Even its yield per acre is greater than that of the terrestrial crops. Algae is broadly divided into two types, macroalgae and microalgae. We know that majority of researchers concentrate on producing biofuels from microalgae. Here the author has done work for production of macro algae and the energy utilization from it by various methods such as pyrolysis, gasification, transterification for biodiesel, hydrothermal liquefaction, anaerobic digestion etc. It was found that anaerobic digestion is the closest process to extract energy from maroalgae. It can play a big role along with other method in conjunction to produce biofuel from macroalgae in future [15].

As we know that, pollution problems are increasing day by day. Also prices of the fossil fuels are increasing. This increase in prices is due to depletion of fossil fuels. Thus an alternative fuels are necessary to use in CI engine. Algae biofuel has the potential to be the alternative fuel which can be used in IC engines. Some algae species have high lipid content upto 50 percent of its biomass. Hence, here we are using algae biodiesel as fuel in the diesel engine and carrying out the analysis of performance, combustion and emission characteristics in the computerized VCR diesel engine.

2. MATERIALS AND METHODS

2.1 Extraction and production of algae biodiesel

Algae has many species like Spirulina, Chlorella, Spirogyra, Euglena gracilis, pond water algae etc. which have been identified and can be cultivated for biodiesel production. Here we have selected Spirulina species of algae.

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The algae biodiesel was been obtained from INDIAN BIODIESEL CORPORATION, Baramati. The cultivation of algae requires a lot of conditions that must be maintained. In IBDC, the spirulina powder for readily imported as its purity is much of a concern. Later algae biodiesel was prepared from that algae powder in IBDC , Baramati. This purity depends upon the method of cultivation. There are various methods for production of microalgae such as pyrolysis, gasification, transterification for biodiesel, hydrothermal liquefaction, anaerobic digestion etc.

Various processes carried out for biodiesel production from algae raw material have been explained in brief below. Lets first see the flow chart of algae biodiesel production and later study it briefly. In production of algae biodiesel the first step is to select the proper species of algae biomass. Later this biomass is dried and grinded in fine powder form. In our case spirulina algae powder was imported and later the oil was extracted using the soxhelt apparatus by using hexane as solvent. Soxhelt mainly consists of parts like boiling flask, extraction chamber, thimble, vapor tube, siphon arm and condenser as shown in below figure. In this process algae powder is placed in thimble and solvent hexane was placed in boiling flask. The solvent is heated and due to heating its vapour rises and passes through the vapour tube to the condenser. Here in the condenser the solvent vapour is cooled using water and liquid drops of hexane pass from condenser to the thimble where it extracts the oil from algae powder and goes again into boiling flask through the siphon arm by siphon effect. This process cycle continues till entire lipid is extracted from the algae powder. Lastly we see that greenish matter is obtained into the flask which is further taken for transesterification process after it is been filtered and demoisturized.

In transesterification process the oil extracted by soxhelt apparatus is converted into biodiesel by using methanol and potassium hydroxide as catalyst. transesterification is the process of converting the fat or oil by using alcohol and a catalyst, into biodiesel (methyl ester) and glycerin. It basically consists of mixing of alcohol (methanol,ethanol) and the catalyst, typically a strong base like NaOH or KOH and then alcohol/catalyst is reacted with the fatty acid i.e. oil so that transesterification reaction takes place.

In our case while transesterification of algae oil, methanol is used as alcohol and potassium hydroxide is used as catalyst. Methanol used in the reaction is 13% of oil quantity and catalyst KOH is 0.6% of oil. The temperature maintained is 55 to 60 degrees and the agitation given is 600 to 700 rpm. The reaction time is 90 minutes. After the reaction is completed it is allowed to settle for 8 to 10 hrs. Now this settled mixture of biodiesel and glycerin is separated to get 80% of biodiesel and 20% of glycerin. The obtained biodiesel is again purified with hot water washing technique and demoisturized at 110 degrees for 20 min. Now the obtained product is 100% algae biodiesel also called as B100.

2.2 Fuel properties of algae biodiesel and diesel

The following fuel properties are as follows in the Table 2.1

Table 2.1 Fuel properties

Sr. no.	Test description	Unit	Diesel	Algal oil biodiesel blends					ASTM Biodiesel Std.
				B10	B20	B30	B40	B50	

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1.	Density	gm/cc	0.832	0.853	0.838	0.840	0.843	0.844	0.8-0.9
2.	Calorific value	MJ/Kg	42.50	42.32	41.77	41.35	41.09	40.80	34-45
3.	Flash point	°C	51	58	66	74	81	88	93
4.	Fire point	°C	56	63	72	79	86	94	-
5.	Viscosity	mm^2/s	2.6	2.78	2.96	3.10	3.23	3.38	1.9-6
6.	Acid No.	mgKOH/g	0.5max	0.453	0.421	0.39	0.382	0.374	0.5 max

2.3 Experimental setup

An experiment was done through a CI engine. The engine was connected to the electrical dynamometer for powering the engine and loading. The compression ratio can be changed by tilting the arrangement or shutting off the engine. The engine was provided with the necessary instrument for the combustion pressure and movement of crank angle measurement, the signals are associated with a computer through the engine to indicate the supplying interfacing airflow, fuel flow, temperature, and load quantifications. The construction consists of a stand-alone panel air box to fuel tanks manometer fuel measuring unit transmitters for airflow measurements, process indicators, and engine indicators for the cooling of water and a calorimeter for the fuel flow of measurement Rotameter were provided as well. LabVIEW-based engine performance analysis software package "EnginesoftLV" was provided for online performance evaluation. The engine specifications as shown in the Table 2.2

Figure 2.1 Smoke meter

Figure 2.2 Engine set-up

Table 2.2: Test rig engine specifications

Product	VCR Engine test setup 1 cylinder, 4 stroke, Diesel(Computerized)
Product code	234
Engine	Make Kirloskar, Type 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 shaft:	With universal joints

Air box	M S fabricated with orifice meter and manometer
Fuel tank	Capacity 15 lit with glass fuel metering column
Calorimeter	Type Pipe in pipe
Piezo sensor	Range 5000 PSI, with low noise cable
Crank angle sensor	Resolution 1 Deg, Speed 5500 RPM with TDC pulse.
Data acquisition device	NI USB-6210, 16-bit, 250kS/s.
Piezo powering unit	Make-Cuadra, Model AX-409
Digital milivoltmeter	Range 0-200mV, panel mounted
Temperature sensor	Type RTD, PT100 and Thermocouple, Type K
Temperature transmitter:	Type two wire, Input RTD PT100, Range 0–100 Deg C,Output 4–20mA and Type two wire, Input Thermocouple, Range 0–1200 Deg C, Output 4–20 mA
Load indicator	Digital, Range 0-50 Kg, Supply 230VAC
Load sensor	Load cell, type strain gauge, range 0-50 Kg
Fuel flow transmitter	DP transmitter, Range 0-500 mm WC
Software	"EnginesoftLV" Engine performance analysis software
Rotameter	Engine cooling 40-400 LPH; Calorimeter 25-250 LPH
Pump :	Type Monoblock
Overall dimensions:	W 2000 x D 2500 x H 1500 mm
Shipping details:	Gross volume 2.46m3, Gross weight 808kg, Net weight 528kg

3. Results and Discussion

3.1 Brake Thermal Efficiency

Above figure 3.1 shows the graph plotted of Load vs Brake thermal efficiency for Diesel and algae biodiesel blends namely B10, B20, B30, B40, B50. It is seen that as the load increases the brake thermal efficiency also increases. The brake thermal efficiency is the ratio of amount of brake power developed to the amount of energy supplied by the fuel. In case of diesel fuel brake thermal efficiency is better than algae biodiesel .This is mainly due to low volatility, high viscosity, low calorific value and low air-fuel mixing ability. Brake thermal efficiency for B40, B50 more as compared to others at high loads. B20 has a similar line behavior as that of diesel fuel in terms of brake thermal efficiency.

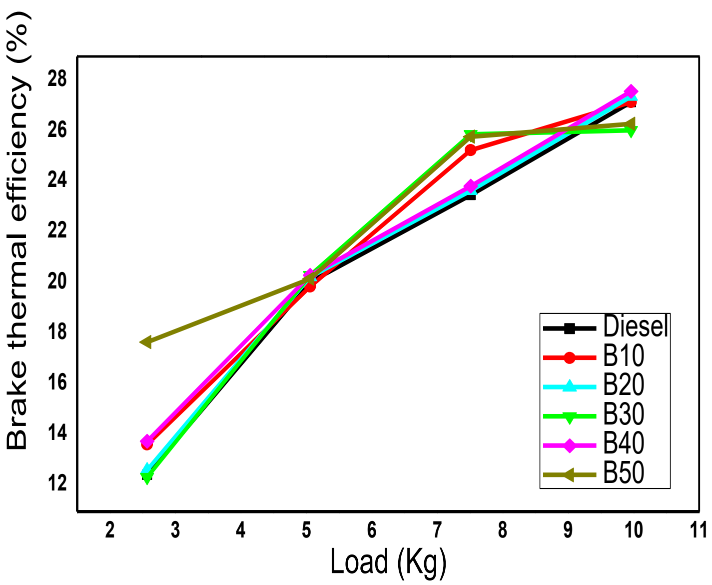

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Figure 3.1 Effect of Load on Brake Thermal Efficiency

3.2 Specific fuel consumption

Above figure 3.2 shows the graph plotted of Load vs Specific fuel consumption for Diesel and algae biodiesel blends namely B10, B20, B30, B40, B50. Specific fuel consumption is nothing but amount of fuel required to produce unit power. It is seen that as the load goes on increasing the SFC for all blends as well as diesel decreases. Comparatively for biodiesel blends SFC is more due to low heating value and high viscosity than that of diesel fuel at higher loads. B20 shows characteristics similar to that of diesel as shown in graph.

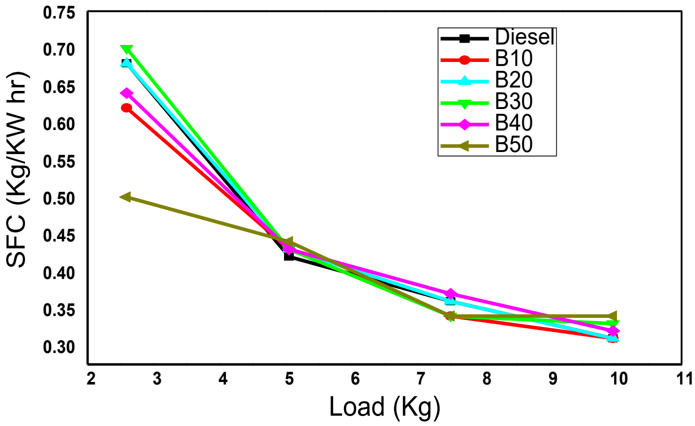

Figure 3.2 Effect of load on Specific fuel consumption

3.3 Smoke emission

HSU stands for Hartridge smoke unit. It is used to measure the smoke density of the smoke which is emitted by vehicles. If the HSU value is less than 65, the vehicle is certified a non polluting. We see from above figure 3.3 that as the load increases the HSU value for all fuels increases. B10 and B20 have less HSU value as compared to diesel. This is mainly as more oxygen is available for complete combustion of biodiesel which available naturally in algae.

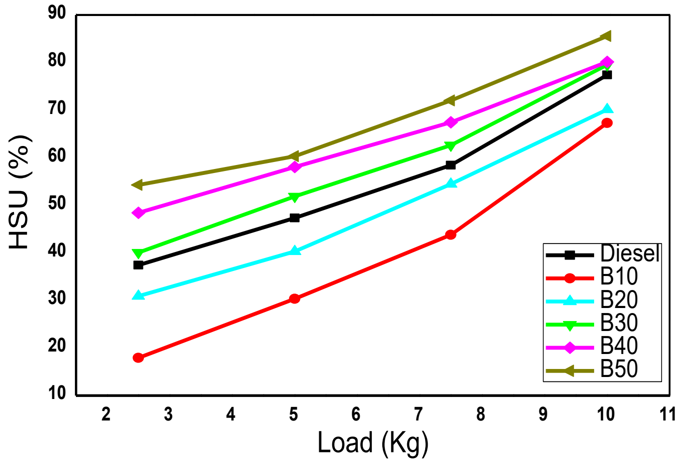

Figure 3.3 Effect of load on smoke emission

3.4 Cylinder pressure vs Crank angle

From the above cylinder pressure figure 3.4 of diesel and algae biodiesel blends B10, B20, B30, B40, B50 it is seen that the pressure changes in both the cases is somewhat similar. From the readings and graph it observed that for B20 the start of combustion is around 20 degree before TDC and the cylinder pressure is around 18 bar which is close to that of diesel. We see the pressure is little on higher side as that for diesel. High pressure during start of combustion gives high temperature which is good for combustion of fuel. The high pressure during start of combustion may be due to higher viscosity and low calorific value of biodiesel. The peak pressure of both diesel and B20 is same which is around 48 bar. It is also observed that the peak pressure increases as the load increases in both the cases.

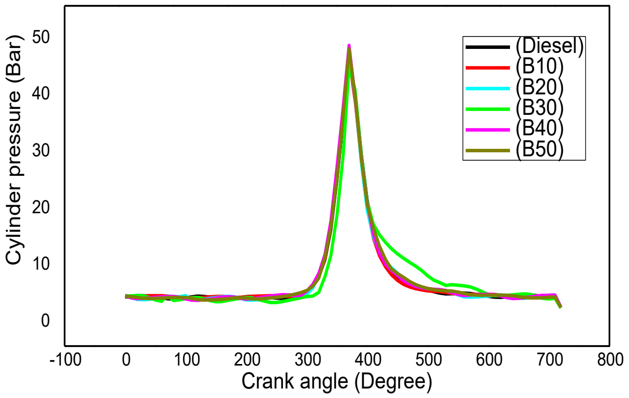

Figure 3.4 Crank Angle vs. Net Heat Release

3.5 Net heat release rate vs Crank angle

Above figure 3.5 shows the heat release rate for diesel and algae blends of algae biodiesel. Heat released is nothing but the energy released after the fuel combustion. This energy is basically chemical energy released in the form of heat. We know that heat release rate increases as the load increases. This is because as load increases more fuel is injected in the cylinder. Thus there are more carbon particles in the cylinder which intern release more heat on combustion. The heat release rate is higher or somewhat similar in algae biodiesel. This mainly due to high viscosity of algae bio diesel a compared to diesel. Due high viscosity the ignition delay period increases leading to high heat release rate. But later as the combustion cycles goes on increasing the temperature in cylinder goes on increases , this ignition delay period also reduces. From above graph we that B10 and B20 show similar behavior to that of diesel.

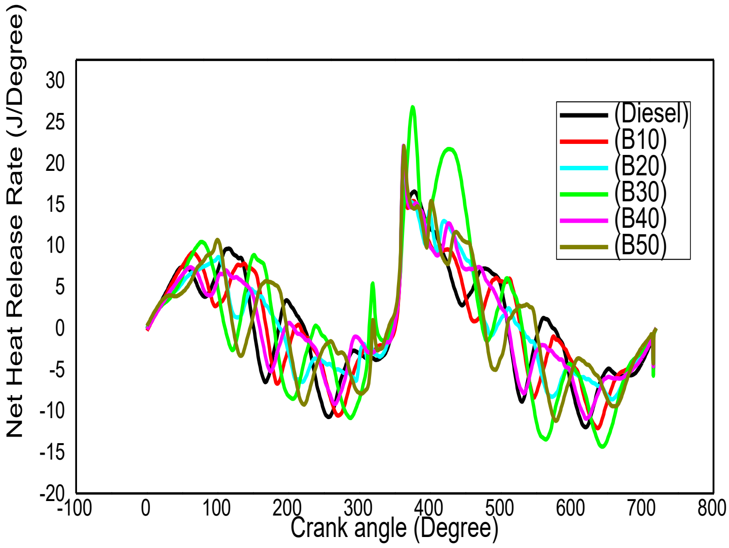

Figure 3.5 Net Heat release rate vs. crank angle

3.6 Mean Gas Temperature

Above figure 3.6 shows us the comparison of the mean gas temperature between the diesel fuelled and Algae biodiesel fuelled VCR engine. Mean gas temperature is the mean temperature of the gas which is produced after the combustion of the fuel and air mixture. This gas travels through various section during the combustion cycle of the engine. So it is necessary to study its average temperature throughout the cycle. Above we see that B10 and B20 show similar behavior to diesel as compared to other blends. Thus B20 shows similar characteristic to that of diesel in case of mean gas temperature and only so can be a potential replacement.

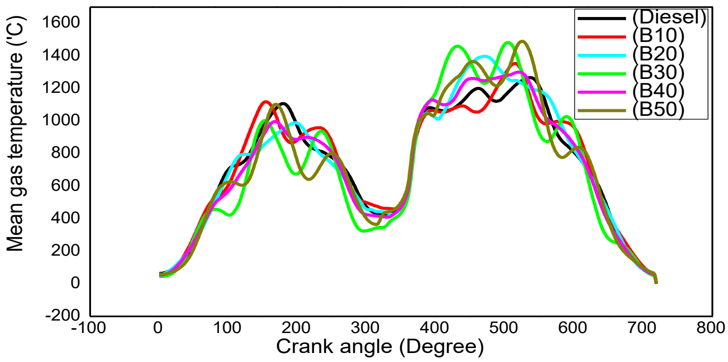

Figure 3.6 Mean gas temperature vs crank angle

3.7 Conclusions

Here we have studied the performance, combustion and emission characteristics of algae biodiesel fueled diesel engine and compared that with diesel fueled engine. It was observed that there is similar behavior of blends B10, B20 and B30 with that of diesel for parameters like brake power, specific fuel consumption, brake thermal efficiency, mechanical efficiency. Among all blends B20 blend shows most close relevance to diesel. In case of cylinder pressure and mean gas temperature B10 and B20 showed similar behavior. Overall between all blends, B20 blend gives very attractive results. Thus B20 can be used for diesel engine.

From studies it was found that there is considerable reduction in the emissions coming from the exhaust of algae biodiesel fueled diesel engine. Hydrocarbon (HC), Carbon monoxide (CO) and carbon dioxide (CO2) emissions are less as there is complete combustion of fuel. This is mainly due to more oxygen available for combustion in algae naturally. Thus the combustion efficiency is increased as compared to diesel. Only there is increase in Nitrous oxides (NOx) emission than that of diesel engine. This is mainly as algae naturally contains about 10% of nitrogen in its composition; also there other factor like combustion temperature and cetane number of fuel. As production of algae does not take a lot of cost and if proper measures are taken for improving the purity of the biodiesel produced we can get very good results. Overall Algae biodiesel is a very good alternative option for use of diesel in diesel engines.

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