EXPERIMENTAL INVESTIGATION ON PERFORMANCE AND EMISSION CHARACTERISTICS OF A DIESEL ENGINE FUELED WITH NERIUM OIL AS BIODIESEL

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Abstract*— *Homogeneous Charge Compression Ignition engines have potential to provide like efficiencies and very low NOx and particulate matter emissions. There is growing global interest in using alternative biofuels in order to reduce the reliance on conventional fossil fuels. Therefore this experimental study was carried out to investigate performance and emission characteristics of HCCI engine fuelled with Nerium oil and compare it with baseline diesel fuel. The experiments were conducted on a modified single cylinder four-stroke engine at different engine speeds using port fuel injection technique for preparing homogeneous charge. To achieve auto-ignition of air–fuel mixture in the combustion chamber, intake air pre-heater was used. The results show that nerium oil has good replacements to diesel in HCCI combustion mode.

Index Terms*— *Homogeneous Charge Compression Ignition engines, Nerium oil, Emission.

I. INTRODUCTION

IC engines have played a key role, both socially and economically, in shaping of the modern world. Their suitability as an automotive power plant, coupled with a lack of practical alternatives, means road transport in its present form could not exist without them. However, in recent decades, serious concerns have been raised with regard to the environmental impact of the gaseous and particulate emissions arising from operation of these engines. As a result, ever tightening legislation, that restricts the levels of pollutants that may be emitted from vehicles, has been introduced by governments around the world. In addition, concerns about the world's finite oil reserves and, more recently, by CO_2 emissions brought about climate change has lead, particularly in Europe, to heavy taxation of road transport, mainly via on duty on fuel. These two factors have lead to massive pressure on vehicle manufacturers to research, develop and produce ever cleaner and more fuel-efficient vehicles. Though there are technologies that could theoretically provide more environmentally sound alternatives to the IC engine, such as fuel cells, practicality, cost, efficiency and power density issues will prevent them displacing IC in the near future.

Over the last 30 years, levels of NOx, CO and CO_2 emissions from vehicles have been dramatically reduced and this has largely been achieved by the use of exhaust gas after-treatment systems, such as the catalytic converter. This has been motivated by a continually tightening band of legislation related to emission of these pollutants that has been enforced in the United States, Japan and Europe.

Recent studies and research have made it possible to extract bio-diesel at economical costs and quantities. The blend of Bio-diesel with fossil diesel has many benefits like reduction in emissions, increase in efficiency of engine, higher cetane rating, lower engine wear, low fuel consumption, reduction in oil consumption etc. It can be seen that the efficiency of the engine increases by the utilization of Bio-diesel. This will have a great impact on Indian economy.

II. LITERATURE REVIEW

Kihyung Lee, Kihyung Lee, Changsik Lee Jeaduk Ryu and Hyungmin Kim, "An Experimental Study on the Two-Stage Combustion Characteristics of a Direct-Injection-Type HCCI Engine", (2005)- To investigate the combustion and emission characteristics of the HCCI engine, we evaluated the influence of intake air temperature, pressure, and an additive on HCCI combustion and emission performance characteristics; in particular, we focused on those characteristics of the cool and hot flame, the auto-ignition time, and the indicated mean effective pressure under various engine running conditions. In the rich-mixture region, the ignition delay was inversely proportional to the intake temperature. However, in the lean mixture region, an inverse trend occurred. Advancing the auto-ignition time increased the HCCI engine output; however, excessive advancement led to a decrease of the IMEP and an increase in NOx emissions due to knocking.

D. Yap, J. Karlovsky, A. Megaritis , M.L. Wyszynski, H. Xu, "An investigation into propane Homogeneous Charge Compression Ignition engine operation with residual gas trapping", (2005)- Homogeneous charge compression ignition engines requires various approaches such as high compression ratios and inlet charge heating to achieve auto ignition. Moderate engine compression ratio the achievable engine load range was controlled by the degree of internal trapping of exhaust gas supplemented by inlet charge heating. NOx emissions were characteristically low due to the nature of homogeneous combustion. Residual gas trapping is an effective method in reducing intake temperature requirements with HCCI combustion as it allowed stable operation.

A.Tsolakis, A.Megaritis "Partially Premixed Charge Compression Ignition engine with on-boardH2 production by exhaust gas fuel reforming of diesel and biodiesel", (2005)- The technique involves the injection of hydrocarbon fuel into a catalytic reformer fitted into the Exhaust Gas Recirculation system, so that the produced gas mixture is fed back to the engine as reformed EGR. The potential of the technique in terms of achieving reduction of smoke and NOx emissions and improved fuel economy. Important guidelines required for the design as well as the operation of such a close coupled engine-reformer system can be developed from the present work.

ZhiWang , Shi-Jin Shuai, Jian-Xin Wang, Guo-Hong Tian, "A computational study of direct injection gasoline HCCI engine with secondary injection", (2006)- The improved 3D CFD/chemistry model was validated using the experimental data from HCCI engine with direct injection. Then, the CFD/chemistry model has been employed to simulate the intake, spray, combustion and pollution formation process of gasoline direct injection HCCI engine with two-stage injection strategy. HCCI load range can be extended. However, the periphery of fuel-rich zone leads to fierce burning, which results in slightly high NOx emissions. Two-zone HCCI creates advanced ignition and stratified combustion, this makes ignition timing and combustion rate controllable.

QIAN Zuo-qin, LÜ Xing-HCCI "Characteristics of HCCI engine operation for additives, EGR, and intake charge temperature while using iso-octane as a fuel", (2006)- The effects of Exhaust Gas Recirculation and operation parameters including engine speed, equivalence ratio, coolant-out temperature, and intake charge temperature on the basic characteristics of a single-cylinder Homogeneous Charge Compression Ignition engine powered with reformulated iso-octane fuels.The combustion timing advances with the increase of DTBP concentrations, coolant temperature and equivalence ratio. the ignition timing advances with the increase of the DTBP addition, coolant temperature, equivalence ratio and intake charge temperature.

Myung Yoon Kim, Jee Won Kim, Chang Sik Lee, and Je Hyung Lee "Effect of Compression Ratio and Spray Injection Angle on HCCI Combustion in a Small DI Diesel Engine", (2006)- A small Direct Injection diesel engine equipped with a common-rail injection system to find the optimal operating conditions of a Homogeneous Charge Compression Ignition engine. To realize this fundamental concept and find the optimal operating conditions, injection timing was varied from Top Dead Center to 80° before TDC and up to 45% of Exhaust Gas Recirculation was tested. The modification of the combustion chamber shape and injection angles fitted for early timing injection resulted in a high IMEP for an early timing injection.

Lu Xing HCCI , Hou Yuchun, ZuLinlin, Huang Zhen, "Experimental study on the auto-ignition and combustion characteristics in the homogeneous charge compression ignition (HCCI) combustion operation with ethanol/n-heptanes blend fuels by port injection", (2006)- Homogeneous Charge Compression Ignition combustion engines fuelled with n-heptanes and ethanol/n-heptanes blend fuels. Due to the much higher octane number of ethanol, the cool flame reaction delays, the initial temperature corresponding the cool-flame reaction increases, and the peak value of the low-temperature heat release decreases with the increase of ethanol addition in the blend fuels. For all ethanol/n-heptanes blend fuels, the combustion duration is longer than neat n-heptanes at light load.

DaeSik Kim a, Chang Sik Lee, "Improved emission characteristics of HCCI engine by various premixed fuels and cooled EGR", (2006)- The premixed fuel is supplied via a port fuel injection system located in the intake port of DI diesel engine. . The premixed fuels used in this experiment are gasoline, diesel, and n-heptanes. EGR can suppress the advanced and sharp combustion at high inlet temperatures. Accordingly, knocking timing is shifted toward higher premixed ratios in proportion to increases in the EGR rate.

Mingfa Yao, Zheng Chen, Zunqing Zheng, Bo Zhang, Yuan Xing "Study on the controlling strategies of homogeneous charge compression ignition combustion with fuel of di methyl ether and methanol", (2006)- Exhaust Gas Recirculation rate and DME percentage are two important parameters to control the HCCI combustion process. The combustion efficiency largely depends on DME percentage, and EGR can improve combustion efficiency. In normal combustion, adopting large DME percentage and high EGR rate can attain an optimal HCCI combustion. NOx emissions are ultra-low in normal combustion. EGR cannot extend the maximum IMEP of HCCI operation range fueled by DME and methanol, but can enlarge the DME percentage range in normal combustion.

Song-Charng Kong "A study of natural gas/DME combustion in HCCI engines using CFD with detailed chemical kinetics", (2007)-Combustion, nitrogen oxides emissions and effects of fuel compositions on engine operating limits were well predicted by the present model. Present engine exhibits HCCI combustion characteristics including two stage ignition, low combustion temperatures and low NOx emissions. Engine operating limits can be established by using the present model and good levels of agreement with experimental results were obtained.

WANG Zhi, WANG Jianxin, SHUAI Shijin, MA Qingjun, TIAN Guohong, "Control of homogeneous charge compression ignition combustion in a two-cylinder gasoline direct injection engine with negative valve overlap", (2007)- HCCI combustion was studied in a two-cylinder Gasoline Direct Injection engine with Negative Valve Overlap. The experimental results indicated that the coefficient of variation of the engine cycle decreased by using NVO with two-stage direct injection. The combustion system with multi-injection was validated and the corresponding HCCI combustion can be controlled. The advantages of rapid response, high stability, low fuel consumption, low emission and wide operational region.

III. METHODOLOGY

Although advantageous over traditional engines in thermal efficiency and NOx emission, HCCI combustion has several main difficulties. The major problem blocking progression to commercial production of HCCI engine is the narrow operating ranges limited by knocking or violent combustion at high loads and partial burn or misfire at low loads.

These following difficulties made in engine

- Dual mode combustion Control of combustion timing
- Limited power output
- Homogenous mixture preparation
- Weak cold-start capability
- High peak pressure High heat release rates

The processed form of vegetable oil has emerged as a potential substitute for diesel fuel on account of its renewable source and lesser emissions. However, use of straight vegetable oil has encountered problem due to its high viscosity. The blended fuels could lead to higher CO and HC emissions then biodiesel, higher CO emissions but lower HC emission then the diesel fuel. There are simultaneous reductions of NO_x and PM to a level below those of the diesel fuel. From the lower heating value of bio-fuel some increase of fuel consumption.

3.1 Implementation of Concept to Reduce the Problem

The first is to control the phasing and rate of combustion for best fuel economy and lowest pollutant emissions. Unlike SI combustion, HCCI combustion is achieved by controlling the temperature, pressure and composition of the in-cylinder mixture through the following parameters:

- EGR or residual rate
- air/fuel ratio
- Compression ratio
- Inlet mixture temperature

- Inlet manifold pressure
- Fuel properties or fuel blends
- Injection timing of a DI gasoline engine
- Coolant temperature.

Variable valve actuation allows fast and individual cylinder-based direct control over EGR/residual gases and effective CR, so that mixture temperature and composition can be altered for indirect control of combustion phasing. Fast thermal management based approach intends to control directly the mixture temperature and hence the combustion phasing. The employment of lean mixture has been found to be beneficial to slow down the heat release rate but air charging would be needed to provide the extra air required. Perhaps, a more interesting recent development in combustion phasing control is the use of direct injection and appropriate injection strategies. Several studies have shown that direct fuel injection can be used to influence HCCI engines for the automotive industry the HCCI combustion by altering not only the local fuel distribution but more importantly the in-cylinder temperature history through early low temperature heat release and charge cooling. In addition, direct injection strategy can also have a direct influence on the region of HCCI operation.

Another major hurdle blocking progression to commercial production of HCCI engines is the limited operating boundary compared with traditional SI operation. Knocking or violent combustion at high load and partial-burn or misfire at low load are the two main limiting regions in HCCI combustion in the gasoline engine. Boosting has been shown to extend the high load region of HCCI operation when it is combined with leaner mixture. In the case of residual gas trapping method, the use of cooled EGR has been shown to extend the upper boundary of HCCI operation by retarding the start of HCCI combustion. Another interesting and potentially very effective way to lift the HCCI combustion to the high load region is through the use of two-stroke operation in two-stroke/four-stroke switching engines, since for the same imep, the two-stroke HCCI operation will produce twice the torque of the four-stroke operation. Perhaps of equal importance is the ability of HCCI combustion to be operated at lower load conditions. Recent studies have shown that spark ignition can assist HCCI combustion towards lower load operations by providing more favorable in-cylinder conditions for auto-ignition to take place. The presence of spark also allowed lower compression ratio or lower inlet air temperature to be used for HCCI operation.

In some studies, spark assisted HCCI combustion has been found to facilitate the transition between SI and HCCI combustion when it occurs at the boundary between the two combustion modes with internal EGR/residual gas operated HCCI, whilst spark discharge was found to cause greater cyclic variations between mode transfer from HCCI to SI with thermally activated HCCI operation using high compression ratio and fast thermal management. Extended the spark assisted HCCI concept to SI and HCCI hybrid combustion by igniting a stratified charge near the spark plug first so that the pressure rise associated with the early heat release from the SI combustion caused the premixed and diluted mixture to auto ignite and burns. As a result, the maximum IMEP value could be increased but it was accompanied with higher NOx emissions than pure HCCI operation. There are also other techniques that can be used to expand both the high load and low load regions of HCCI operation. One such method is through regulating coolant water temperature.

3.2 Preparation of Biodiesel

The vegetable oil is the important criteria for the biodiesel. The selection of the biodiesel should be unique and it should have some properties which can make the difference between the previous researches. The Nerium oil is selected for the experimentation of the biodiesel. The reason for choosing Nerium oil is it is available in the market and less cost. In India, rice is produced largely in southern parts so it can help in easy making of Nerium oil. Comparing to the other oils Nerium oil has investigated very less and it has scope for many modifications.

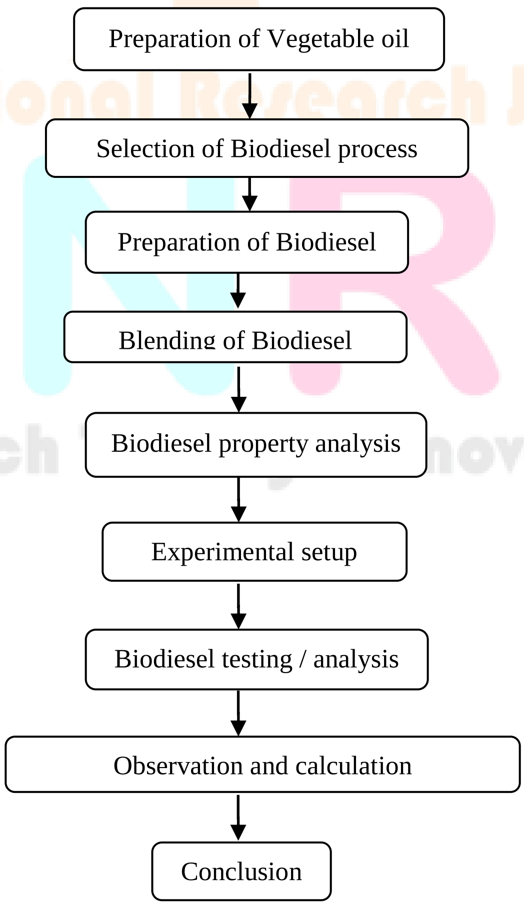

Figure 3.1 Methodology

3.3 Nerium oil as Biodiesel

Neriumis an evergreen small tree. It is called as Aralli in tamil and most commonly known as oleander. It grows well in warm subtropical regions up to 6 m. It is usually planted along the road sides due to the beautiful colour of flowers. Its closer cetane number motivated to select it as a source of fuel. It has substantial flash and fire point values. The calorific value is almost nearer to conventional diesel and superior than other biodiesels. These are the reasons behind the motivation of studying Nerium biodiesel as a source of fuel.

3.4 Extraction of Nerium oil

The apparatus required for extraction of oil from Nerium seeds are Soxhlet apparatus, Condenser, Round bottom flask, Stirrer, Heating mandrel and the integrities required for extraction of Nerium oil are Hexane solution and Crushed seeds. The procedure required for production of Nerium oil is illustrated in the following steps.

1. Initially the crushed seeds are placed into the main chamber of the Soxhlet extractor.
2. The Soxhlet extractor is then placed onto a round bottom flask containing the extraction solvent (hexane) which is then equipped with a condenser.
3. Here the solvent is heated to about 40-50 degree Celsius. Due to this heat, the solvent vapour travels up to a distillation arm to condenses, and drips back down into the main chamber, then, the oil dissolves in the warm solvent and runs back to the distillation flask.
4. This cycle is carried out for about 4-5 hours.

Figure 3.2 Nerium seeds without outer shells

Figure 3.3 Sexhlet apparatus

3.5 Properties of Diesel and Nerium Oil

Table 3.1 Properties of Diesel and Nerium Oil

Character	Diesel	Nerium oil
Kinematic viscosity(40^{0}C)	2.75	3.6
Density (kg/m^3)	835	850
Calorific value in KJ/kg	43200	42923
Cloud point in ^{0}C	-15	2
Flash point in ^{0}C	66	70
Fire point in ^{0}C	64	83
Cetane number	47	45

IV. EXPERIMENTAL SET UP

The biodiesel can be prepared by opting suitable instruments. The selection of instruments is based on the criteria. The mechanical stirrer is the most necessary to mix the vegetable oil and diesel. Ultra-sonicator is also used to mix the vegetable oil to the diesel. The vegetable oil has to be processed to remove their fatty acids present in them and the vegetable oils will have certain other compounds in it which has to remove by transesterification process.

4.1 Preparation of nerium biodiesel by transesterification

It is most commonly used and important method to reduce the viscosity of vegetable oils. In this process triglyceride reacts with three molecules of alcohol in the presence of a catalyst producing a mixture of fatty acids, alkyl ester and glycerol. The process of removal of all the glycerol and the fatty acids from the vegetable oil in the presence of a catalyst is called transesterification. The best method for the production of biodiesels is the transesterification of vegetable oils with an alcohol. Vegetable oils are converted into biodiesel by the process of transesterification so as overcome the properties of pure vegetable oils such as high viscosity and low volatility. The reaction is based on one mole of triglyceride reacting with three moles of methanol or ethanol to produce three moles methyl or ethyl esters and one mole glycerol. To reduce the viscosity of the nerium oil, trans-esterification method is adopted for the preparation of biodiesel.

4.2 Methyl ester of nerium oil

The transesterification of Nerium biodiesel was performed as follows;

1. 1000ml of Nerium oil is taken in a three way flask. 12 grams of potassium hydroxide (KOH) and 200 ml of methanol (CH_3OH) are taken in a beaker. The potassium hydroxide (KOH) and the alcohol are thoroughly mixed until it is properly dissolved. The solution obtained is mixed with Nerium oil in three way flask and it is stirred properly.
2. The methoxide solution with Nerium oil is heated to 60^{0}c and it is continuously stirred at constant rate for 1 hour by stirrer. The solution is poured down to the separating beaker and is allowed to settle for 4 hours. The glycerin settles at the bottom and the methyl ester floats at the top. Methyl ester is separated from the glycerin. This coarse biodiesel is heated above 100°C and maintained for 10-15 minutes to remove the untreated methanol.

3. Certain impurities like potassium hydroxide (KOH) etc are still dissolved in the obtained coarse biodiesel. These impurities are cleaned up by washing with 350 ml of water for 1000 ml of coarse biodiesel. This cleaned biodiesel is the methyl ester of Nerium oil.

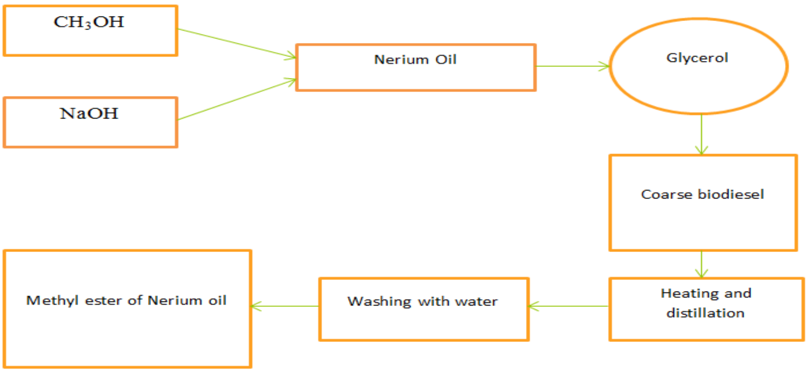

Figure 4.1 Methyl ester of Nerium oil

4.3 Test Procedure

The engine testing for the given fuel is done in the experimental setup has certain test procedure.Fuel flow rate is obtained on the gravimetric basis and the air flow rate is obtained on the volumetric basis. Emission is obtained using an AVL Di gas analyzer working on electro chemical principle. AVL 437 smoke meter is used to measure the smoke capacity, in terms of Hartridge Smoke Unit. All the measurements were obtained and recorded by a data acquisition system. A burette is used to measure the fuel consumption for a specified time interval. During this interval of time, the fuel consumption is measured with the help of stop watch. The engine is made to run using biodiesel of various blends and also with the addition of additives to the biodiesel of the same blends at constant speed about 1500 rpm for nearly 5 minutes to attain the steady state condition at the lowest possible load. The observations were made twice for averaging / concordance. Various parameters like fuel consumption, brake thermal efficiency, emissions are measured at various load ranges.

4.4 Experimental Procedure

The filters of the engine are replaced and the injectors were cleaned and calibrated according to the desired specifications. The gas analyzer and smoke meter were installed. The input to the gas analyzer was taken from the exhaust port of the engine. The fuel tank was then filled with diesel and the engine was run. The engine was run at various loads of the dynamometer – 20, 40, 60, 80, 100 kgs and respective readings were taken for fuel consumption/ sec. The readings of gas analyzer and smoke meter were noted in each case. After all the readings were taken; the leftover diesel was drained out of the tank. The biodiesel was prepared in different blends and the biodiesel. The prepared biodiesel was poured into fuel tank. Same steps were taken and the readings were noted down for the bio-diesel. After taking all the observations, graphs were plotted to compare the performance characteristics and emission characteristics of the engine in case of diesel and bio-diesel.

V. OBSERVATIONS

5.1 Observation For The Performance Parameter

The manometer readings of the engine setup have been noted for calculating the performance parameters of the engine of the corresponding fuel. The readings have been noted for the various blends of the biodiesel and the observation is noted for the various loads and they are listed below.

Table 5.1 Performance Parameter for Diesel

% of load	**calculated load**		**time taken for 10cc of fuel consumptions**		
	N	**kgf**	**t_1 (sec)**	**t_2(sec)**	**t_{avg}(sec)**
20	33.354	3.4	45.79	45.12	45.46
40	67.689	6.9	34.50	34.18	34.34
60	101.043	10.3	28.29	28.51	28.39
80	135.378	13.8	23.63	24	23.63
100	169.713	17.3	18.77	18.64	18.77

Table 5.2 Performance Parameter for Nerium oil blend of 25%

% of load	**calculated load**		**time taken for 10cc of fuel consumptions**		
	N	**kgf**	**t_1 (sec)**	**t_2(sec)**	**t_{avg}(sec)**
20	33.354	3.4	49.50	49.10	49.3
40	67.689	6.9	37.87	38.71	38.29
60	101.043	10.3	29.50	29.38	29.44
80	135.378	13.8	23.15	24.18	23.67
100	169.713	17.3	20.19	21.22	20.21

Table 5.3 Performance Parameter for Nerium oil blend of 50%

% of load	calculated load		time taken for 10cc of fuel consumptions		
	N	kgf	t_1 (sec)	t_2(sec)	t_{avg}(sec)
20	33.354	3.4	46.15	46.12	46.14
40	67.689	6.9	36.83	36.12	36.48
60	101.043	10.3	29.4	28.15	28.78
80	135.378	13.8	22.12	22.61	22.37
100	169.713	17.3	20.16	19.18	19.67

Table 5.4 Performance Parameter for Nerium oil blend of 75%

% of load	calculated load		time taken for 10cc of fuel consumptions		
	N	kgf	t_1 (sec)	t_2(sec)	t_{avg}(sec)
20	33.354	3.4	45.02	45.10	45.09
40	67.689	6.9	37.10	37.67	37.39
60	101.043	10.3	24.07	24.09	24.08
80	135.378	13.8	22.19	22.01	22.08
100	169.713	17.3	19.10	19.07	19.04

Table 5.5 Performance Parameter for Nerium oil blend of 100%

% of load	calculated load		time taken for 10cc of fuel consumptions		
	N	kgf	t_1 (sec)	t_2(sec)	t_{avg}(sec)
20	33.354	3.4	44.12	44.07	44.1
40	67.689	6.9	38.10	35.010	38.09
60	101.043	10.3	24.07	24.35	24.21
80	135.378	13.8	22.12	22.36	22.24
100	169.713	17.3	20.19	19.18	19.69

5.2 Observation for the Emission Parameter

The emission coming out from the engine has to be noted to know the amount of gases coming out from the engine. The amount of the gases is observed with the help of five gas analyzer and the smoke intensity property is noted by using the smoke meter and these instruments helps in observing the emission data. The emission readings for biodiesel noted at same loads which are done for the blends.

Table 5.6 Emission Parameter for Diesel

Load	EGT	smoke density	CO	HC	CO_2	O_2	NO_x
%	^0C	HSU	%by volume	ppm	%by volume	%by volume	Ppm
20	186	20.1	0.09	34	2.40	17.26	346
40	232	34.7	0.08	35	3.20	16.04	657
60	287	49.8	0.06	59	3.9	15.05	846
80	356	59.8	0.12	64	6.4	13.52	1081
100	410	67.3	0.14	71	7	12.61	1258

Table 5.7 Emission Parameter for Neriumoil blend of 25%

Load	EGT	smoke density	CO	HC	CO_2	O_2	NO_x
%	^0C	HSU	%by volume	ppm	%by volume	%by volume	Ppm
20	204	30.6	0.04	39	4.10	17.79	204
40	234	42.8	0.07	40	5.20	17.10	416
60	257	56.2	0.14	47	6.10	16.43	786
80	315	67.3	0.22	52	5.80	15.83	918
100	374	68.6	0.31	67	6.80	14.10	1220

Table 5.8 Emission Parameter for Neriumoil blend of 50%

Load	EGT	smoke density	CO	HC	CO_2	O_2	NO_x
%	^0C	HSU	%by volume	ppm	%by volume	%by volume	Ppm
20	186	40.6	0.04	38	4.80	17.22	201
40	230	52.1	0.05	36	5.10	16.55	381
60	267	67.3	0.11	49	6.10	14.20	736
80	304	80.4	0.22	51	6.70	12.46	908
100	367	88.1	0.36	67	7.20	11.10	1102

Table 5.9 Emission Parameter for Nerium oil blend of 75%

Load	**EGT**	**smoke ensity**	**CO**	**HC**	**CO_2**	**O_2**	**NO_x**
%	**^{0}C**	**HSU**	**%by volume**	**ppm**	**%by volume**	**%by volume**	**ppm**
20	186	42.6	0.06	46	3.60	16.80	200
40	236	57.3	0.06	69	4.20	15.31	351
60	289	69.8	0.09	81	5.70	14.67	630
80	364	80.6	0.11	67	5.80	10.53	804
100	409	98.3	0.24	98	6.90	11.12	918

Table 5.10 Emission Parameter for Nerium oil blend of 100%

Load	**EGT**	**Smokedensity**	**CO**	**HC**	**CO_2**	**O_2**	**NO_x**
%	**^{0}C**	**HSU**	**%by volume**	**ppm**	**%by volume**	**%by volume**	**ppm**
20	180	56.2	0.08	35	3.40	17.72	186
40	216	63.1	0.06	45	4.20	17.12	309
60	275	78.9	0.10	43	5.70	16.13	536
80	315	89	0.09	50	5.40	15.27	701
100	370	98.1	0.34	67	6.70	11.10	819

VI. PERFORMANCE CALCULATION

The performance calculation for the experimental setup is done based on the observed readings for the biodiesel for various loads. The load calculation helps in obtaining the efficiency and fuel consumption for the various blends of biodiesel.

1. Brake Power (BP) = $\frac{2\pi NT}{60 \times 1000}$
2. Total Fuel Consumption (TFC) = $\frac{x \times C_p \times 3600}{t \times 1000}$
3. Specific Fuel Consumption (SFC) = $\frac{TFC}{BP}$
4. Brake Thermal Efficiency (η_{BTH}) = $\frac{BP \times 3600}{TFC \times 43500} \times 100$

Table 6.1 Performance Calculation for Diesel

% of load	**t_{avg}(10cc) (sec)**	**EGT °C**	**BP Kw**	**TFC kg/hr**	**SFC kg/kw.hr**	**η_{BP}**
20	45.46	186	1.04	0.651	0.62591	13.222
40	34.34	232	2.08	0.862	0.414296	19.976
60	28.39	287	3.12	1.042	0.334083	24.772
80	23.63	356	4.16	1.252	0.301035	27.491
100	18.77	410	5.2	1.577	0.303184	27.296

Table 6.2 Performance Calculation for Neriumoil blend of 25%:

% of load	**tavg(10cc) (sec)**	**EGT °C**	**BP Kw**	**TFC kg/hr**	**SFC kg/kw.hr**	**ηBP**
20	49.3	204	1.04	0.600243	0.577157	14.33901
40	38.29	234	2.08	0.772839	0.371557	22.27346
60	29.44	257	3.12	1.005163	0.322168	25.68806
80	23.67	315	4.16	1.25019	0.300526	27.53788
100	20.71	374	5.2	1.428875	0.274784	30.11774

Table 6.3 Performance Calculation for Nerium oil blend of 50%:

% of load	**t_{avg} (10cc) (sec)**	**EGT °C**	**BP Kw**	**TFC kg/hr**	**SFC kg/kw.hr**	**η_{BP}**
20	46.14	186	1.04	0.641352	0.616685	13.41992
40	36.48	230	2.08	0.811184	0.389992	21.22057
60	28.78	261	3.12	1.028214	0.329556	25.11217
80	22.37	304	4.16	1.322843	0.317991	26.02545
100	19.67	367	5.2	1.504423	0.289312	28.60531

Table 6.4 Performance Calculation for Nerium oil blend of 75%:

% of load	**t_{avg} (10cc) (sec)**	**EGT °C**	**BP kw**	**TFC kg/hr**	**SFC kg/kw.kr**	**η_{BP}**
20	45.09	180	1.04	0.656287	0.631046	13.11452
40	37.39	236	2.08	0.791442	0.380501	21.74992
60	24.08	289	3.12	1.228904	0.393879	21.01116
80	22.08	364	4.16	1.340217	0.322168	25.68806
100	19.04	409	5.2	1.554202	0.298885	27.68912

Table 6.5 Performance Calculation for Nerium oil blend of 100%:

% of load	t_{avg}(10cc) (sec)	EGT °C	BP kw	TFC kg/hr	SFC kg/kw.hr	η_{BP}
20	44.1	180	1.04	0.67102	0.645212	12.82657941
40	38.09	216	2.08	0.776897	0.373508	22.15711609
60	24.21	275	3.12	1.222305	0.391764	21.12459099
80	22.24	315	4.16	1.330576	0.31985	25.87420645
100	19.69	370	5.2	1.502895	0.289018	28.63439327

VII. PERFORMANCE RESULTS AND DISCUSSIONS

7.1 Performance Results

7.1.1 Total Fuel consumption

The total fuel consumption of the fuel for the particular period of time for the given load of various blends has formulated with the help of the observed reading and they are shown in the figure 7.1. The blends of B25 and B50 have less TFC compared to that of original fuel.

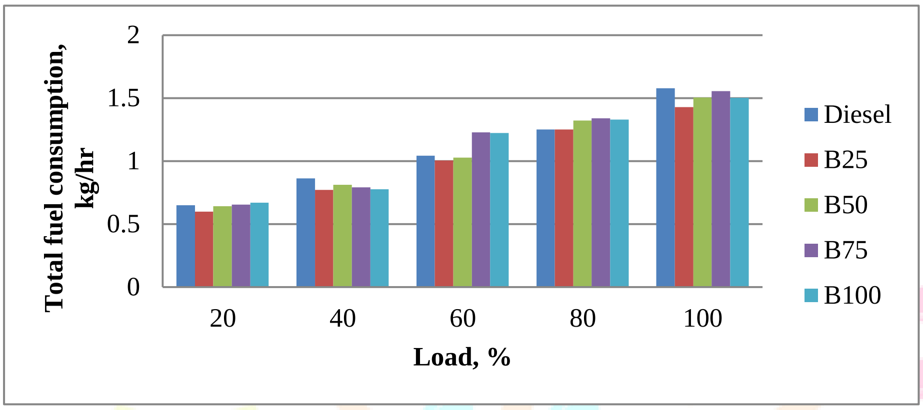

Figure 7.1 Load vs Total fuel consumption

7.1.2 Specific Fuel Consumption

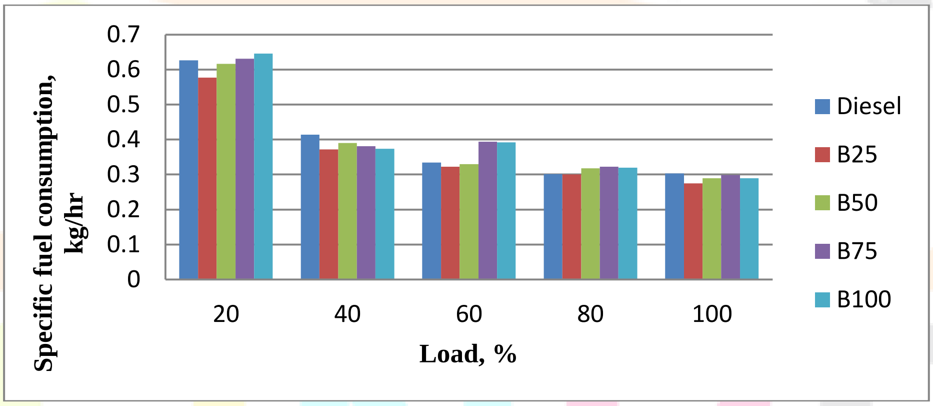

Figure 7.2 Load vs Specific fuel consumption

The results for the specific fuel consumption is obtained with the help of the values of time consumed for the fuel and their results are shown in the graph and it shown below in the figure 7.2. The blends of B25 has good results compared to that of the diesel fuel and the graph gives the detail that the results are proven to have that B25 has similar values to diesel.

7.1.3 Brake Thermal Efficiency

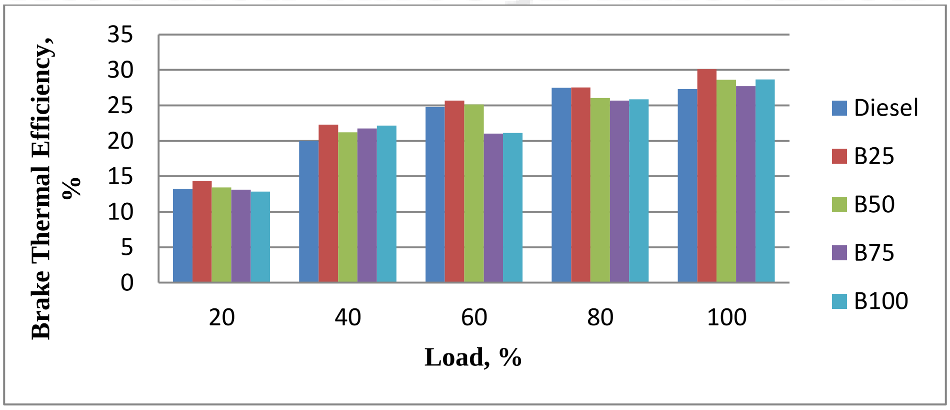

Figure 7.3 Load vs Brake thermal efficiency

The brake thermal efficiency for the various loads of different biodiesel has been plotted and results obtained are shown in figure 7.3 The below graph shows that the blend of B25 has better results compared to the normal diesel fuel. The brake thermal efficiency for the blends of B25& B50 has more results and it ranges similar to that of diesel.

7.2 Emission Results

7.2.1 Smoke density

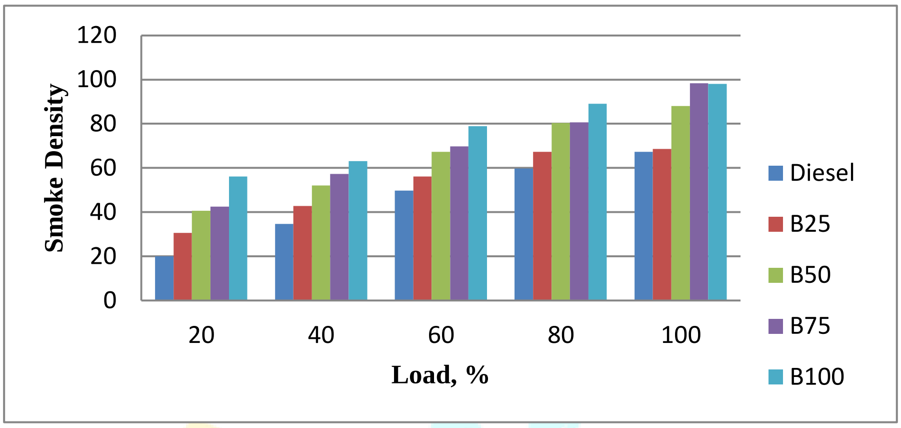

Figure 7.4 Load vs Smoke Density

The variation of the smoke Density was shown in the figure 7.4 for the various loads. The blends of the Nerium oil of B25& B50 with additives have good results compared to that of the blends. The smoke density for the biodiesel is very low when it is at low and minimum load conditions.

7.2.2 Carbon Monoxide

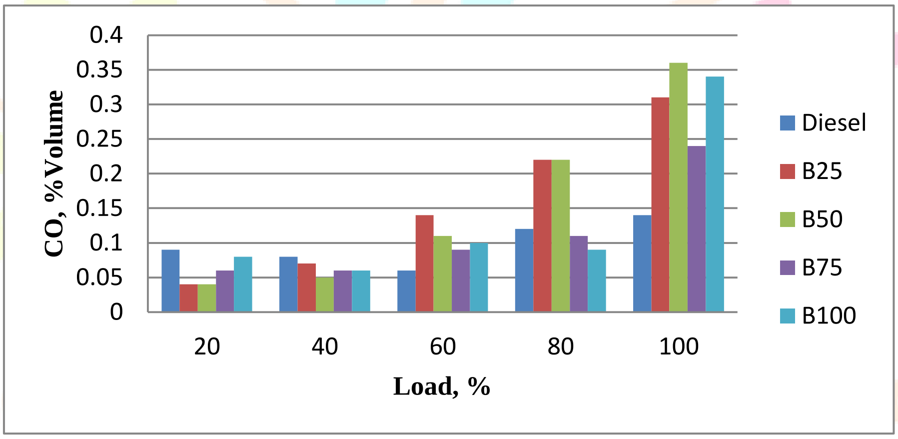

Figure 7.5 Load vs Carbon Monoxide

The graphs shown in the figure 7.5 are drawn between carbon monoxide and the load. The amount of carbon monoxide coming out from the emissions of the biodiesel are higher compared to that of the diesel fuel and the values shown in the graph shows that the variation of the load also increase the percentage of carbon monoxide coming out from the engine.

7.2.3 Unburnt Hydrocarbons

The variation in the amount of unburnt hydrocarbons coming out from the exhaust gases of the diesel engine is represented in the figure 7.6. The levels of hydrocarbons will be high in compared to that of the original fuel because of the certain factors and the ranging level of the increase in hydrocarbons for the diesel and biodiesel will be based higher amount of blends

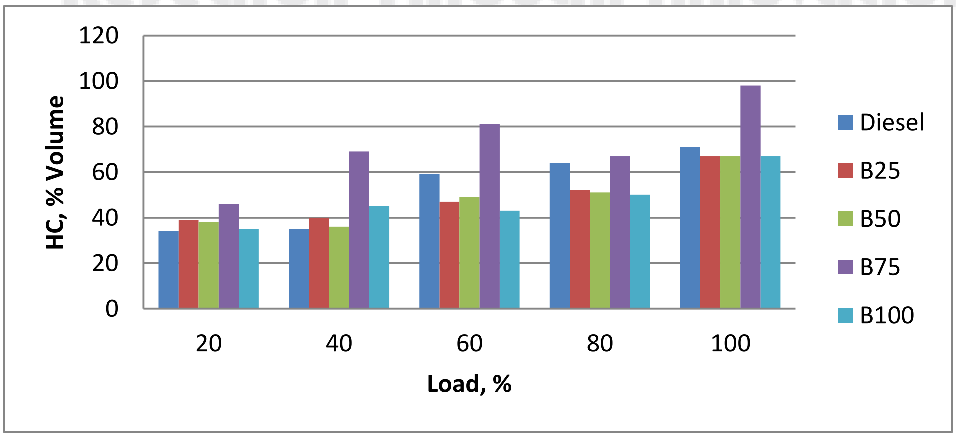

Figure 7.6 Load vs Unburnt Hydrocarbons

7.2.4 Carbon dioxide

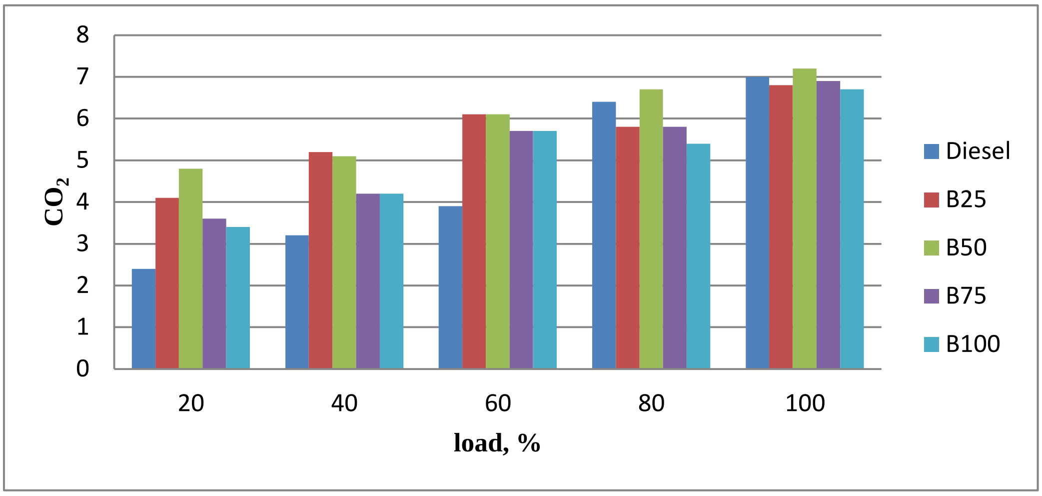

Figure 7.7 Load vs Carbon dioxide

Comparison graphs of the carbon dioxide results for the various loads are shown in the figure 7.7. The data observed from the graph shows that the level of carbon dioxide for the blends of B50 will be less than that of the blend B25.

7.2.5 Oxides of Nitrogen

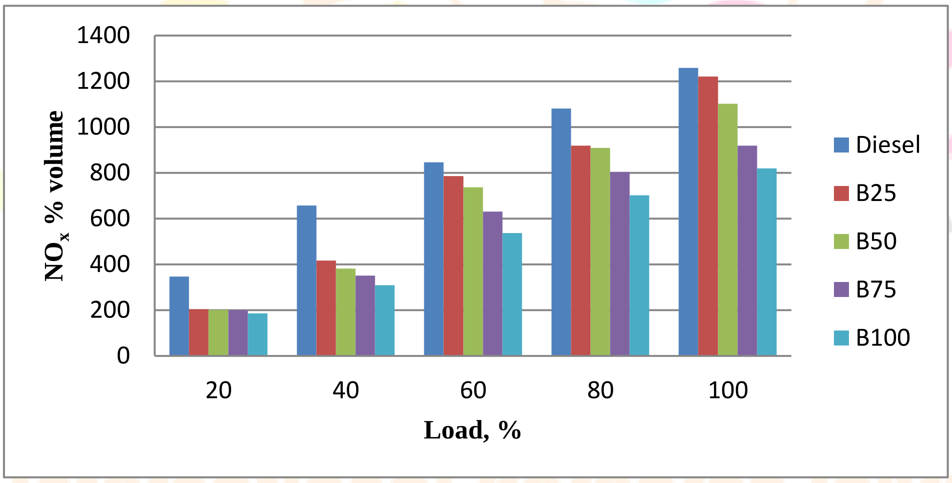

Figure 7.8 Load vs Oxides of Nitrogen

The oxides of nitrogen is observed and plotted has been shown in the graph of the figure 7.8. The oxide of the nitrogen is the main factor which has to be reduced in the emission. The amount of NOx present in the blends of the Nerium oil is less compared to that of the diesel. The blends of B25 & B50 have better results in both forms and it comparatively less than the diesel fuel.

VIII. CONCLUSION

Thus the obtained results are based on their properties of biodiesel and the performance & emission characteristics of Nerium oil were investigated in a single cylinder, constant speed, and direct-injection engine. The brake thermal efficiency of the biodiesel when compared with the diesel there are some results which has relatively results like diesel fuel. The B25 & B50 has better results compared to the other blends of Nerium oil. The Nerium oil blend of 25% has better results similar to that of diesel. The specific fuel consumption and total fuel consumption results of the blended biodiesel have normal results when it is related with the same properties of the diesel fuel. These properties can be improved when the Nerium oil methyl ester is prepared at higher definition. The B25 blend has properties relatively to that of diesel fuel.

It has been clear from the emission results that the oxides of nitrogen (NOx) is very less in the blends of biodiesel compared to that of the diesel fuel operation. The blend of B25 &B50 has very less emission in low load operation. The B75 &B100 has better results at higher loads. So the performance and emission results of the biodiesel has explained that the biodiesel of B25 has better performance parameters.

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