ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

A Comprehensive Study On Performance Of Bio Diesel Fuel For I.C. Engines

Anil Kumar
Research Scholar
Shri JJT University
Rajasthan
anilkadwasra508@gmail.com

Dr. S.Chakradhara Goud
Prof. & Principal
Springfield's Engineering
College Chandrayangutta
cgsakki@gmail.com

ABSTRACT:
In view of the fast depletion of fossil fuel, the search for alternative fuels has become inevitable. Looking at huge demand of diesel for transportation, captive power generation and agricultural sector, the biodiesel is being viewed a substitute of diesel. The performance of diesel engine under the engine loading conditions showed that maximum output power at full load condition is nearly same for B_{10} and diesel fuel. For combustion characteristics, slightly shorter ignition delay and lower peak heat release rates were observed for biodiesel while there is slight reduction in S_{O2} and HC emission with increase in NO_X emission when biodiesel and its blends are used. The present paper covers combustion, performance, and emission characteristics of biodiesel and its blends with diesel. The performance of diesel engines using biodiesel and its blends with petro-diesel in terms of brake power, torque, brake specific fuel consumption (BSFC), thermal efficiency (BTE) and exhaust emissions is reviewed. The engine problems and their possible remedial measure are also suggested in this paper. The engine performance and emission characteristics were studied and compared with pure diesel fuel. Vehicles are the main sources for environmental pollution especially those associated with diesel engines. It causes a number of health diseases and harm to the ecosystem. It is very urgent to find alternative fuel for vehicles. Biofuel is an alternative for vehicles which have potential to reduce engine emissions and maintain the air quality better. In recent years, worldwide biofuel production and use raised drastically. Some developed countries have put their target and mandate to use biofuel. The aim of this review is to discuss the impact of biofuel on diesel engines emission. From this review it is found that biofuel significantly reduces engine emissions and it has potential to reduce more than 80% of GHG emission. Finally, biofuel can be a viable alternative to be used as a transportation fuel.

Key words: biofuel, I.C.Engine, Engine performance

1.0 INTRODUCTION:

Rapid growth of a number of automotive industries in the world has resulted in increase of exhaust emissions to the environment. Vehicular emissions such as particulate matter, hydro carbon, carbon dioxides, carbon monoxides and nitrogen oxides are hugely responsible for the air quality deterioration. Two main internal combustion engine types such as petrol engine and diesel engine contribute to degrade the air quality in the urban environment. There are about 22% of global GHG (greenhouse gas) emissions comes only from the transportation sector due the increasing demand of vehicles. Figure 1 shows the CO_2 emission by transportation sector. The fast emission growth was driven by emissions from road transport sector which increased by 52% since 1990 and accounted for three quarters of transport emission in 2011. The International Energy Agency (IEA) forecasts that the emissions of carbon dioxide (CO_2) from transport sector will increase by 92% between 1990 and 2020 and it is estimated that 8.6 billion metric tons of carbon dioxide will be released to the atmosphere from 2020 to 2035. It has been also reported that, an increase in average global temperature by 2^{o}C will result in death of hundreds of millions of people. It is very urgent to find out alternative fuels for transportation sector as this sector is emitting higher GHG emission and contribute to the rapid growth of global oil demand. Recently, attention has been drawn to develop cleaner alternative fuels from renewable sources to reduce the harmful emission to

ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

the air and to reduce the dependency on the petro-diesel fuel. The most feasible alternative for vehicles being considered globally are biofuel such as biodiesel and ethanol due to their renewable property and reduction of fossil CO_2 discharge which most probably contributes to the global climate changes. Ethanol is produced from a number of crops such as potatoes, sugarcane, grains, corn and sorghum etc whereas, biodiesel can be produced from vegetable oils, recycled waste oil and animal fats. Thus this review aims to investigate the potential of reduction of exhaust emission using biofuel in IC engines either pure or blend form along with the key factor of biofuel development and policies set by government of different countries around the world to use biofuel.

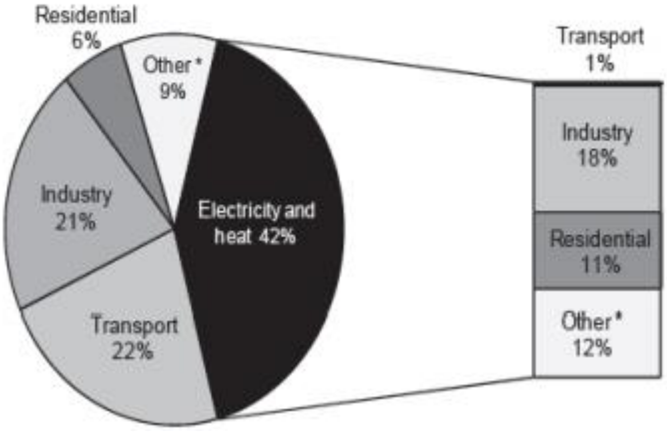


Figure 1: CO_2 emission by sectors

Using biodiesel helps to reduce the carbon dioxide emission to the atmosphere and the dependence on fuel imports, it is renewable in nature and safer to handle, it has no aromatic compounds, practically no sulfur content, and oxygen atoms in the molecule of fuel which may reduce the emissions of CO, total hydrocarbon (THC) and particulate matters (PM). However, biodiesel presents several problems when compared with petroleum diesel fuel such as worse low temperature properties, greater emissions of some oxygenated hydrocarbons and higher production costs. The last of the mentioned problems may be partially solved by using waste cooking oil as the raw material in the transesterification process. Used cooking oil is essentially a waste product and for that reason it is cheaper than unused (virgin) vegetable oil.

ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

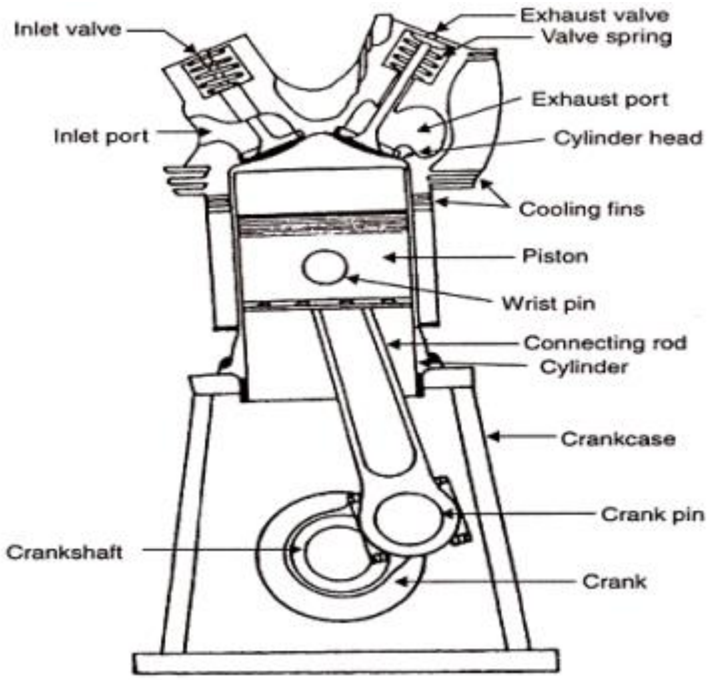


Figure 2: Diagram of I.C Engine

LITERATURE REVIEW:

Sandeep kumar et al [2016] worked on the effects of unleaded iso-octane, unleaded isooctane–ethanol blend (E5) and iso-octane-methanol (M5) blends on engine performance are investigated experimentally in a single cylinder four-stroke spark-ignition engine at a constant 8 Kg load. The engine speed changed from 1100 to 1800 rpm. The results of the engine test showed that ethanol addition to unleaded iso-octane increases the value of IP, FP and IMEP with E5 fuel. The results also showed that the indicated power, brake power, friction power, indicated mean effective pressure, torque, exhaust temperature, and thermal efficiency increases with increase in engine speed. At a constant load of 8 Kg for E5, M5 and iso-octane fuels. Thermal efficiency was maximum for E5 fuel (38.13%) at a speed of 1750 rpm.

Abdel-Rahman and Osman [2012] had tested 10%, 20%, 30% and 40% ethanol of blended fuels in a variable compression- ratio engine and found that the increase of ethanol content increased the octane number, but decreased the heating value. Under various compression ratios of engine, the optimum blend rate found to be 10% ethanol with 90% gasoline.

Venkanna et al [2015] have experimentally investigated on the pressure effect is more important while we would work with biodiesel and diesel blend use as fuel in Kirlosker single cylinder diesel engine. Use of row-honge oil blend with diesel fuel in diesel engine with enhanced injection opening pressure appears to be scare. This research work presented some findings of use of row-honge oil blend with diesel fuel in direct injection diesel engine with increased injection opening pressure. No problem faced at the time of starting the direct injection diesel engine run smoothly. Brake specific fuel consumption of H20 is slightly increasing then diesel. There is performance; emission and combustion parameter of H20 are almost nearer to diesel. For getting best result work with H30, increase pressure from 200 to 225 bars.

3.0 METHODOLOGY:

IC Engine and Its Components

The cylinder and the piston are main components of internal combustion engine, cylinder is the main body of the IC engine moving back and forth to develop power. Cast iron and alloy steel used for making of cylinder & to withstand the wear and tear of the parts, one end of the

ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

cylinder is closed with the help of the cylinder head. Piston rings used in the IC engine. Pistons compress the charge and forcing them towards the crank via connecting rods. It is made of cast steel and aluminum alloy to prevent the leakage of high-pressure gas piston rings. Connecting rods and crankshaft are also main component of the IC engine. Small end of connecting rod is connecting with piston and big end is connecting to crank through the crank pin. Crankshaft used to generate power; it is the backbone of the engine. Intake valves and exhaust valves important, fresh charge enters the inlet valve and the removal of gas is form the exhaust valves. Camshaft, an exhaust manifold and follower, intake manifold, cam, crankcase, carburetor, spark plugs, fuel pump and nozzle are all component for IC engine.

Application of IC Engine:

The engines are in all areas of industry and transport. They used for water, land and air & navy transport. CI engines used for generating electricity. 2-stroke engine used in scooters and used lawnmowers at 2000 to 5000 RPM. They are very simple and maintenance costs are very low. 4- stroke petrol engine used in auto-vehicles like cars, trucks and buses. In the mobile generating sets, these engines are also used. 4-stroke diesel engines are very important now for days, because it has high speed around 100 to 5000 rpm. They also used in cars, buses and trucks. ICEs instigated some of the large electric generators, that the power grid. They found in the form of combustion turbine in combined cycle power plants with a typical electrical output in the range of 100MW to 1GW.

Experimental methods and materials:

In this study, a one-cylinder, four-stroke diesel engine is selected and is mounted on a test-bed. Its major specifications are given in Table 1. The experimental setup with necessary instrumentation has been shown in Fig. 1. In order to supply the fuel to the test engine, two fuel tanks, one for diesel fuel and another for blend fuels were used. The engine is coupled to an eddy current dynamometer. It can be operated at a maximum power of 20 kW at 2450 to 10000 rpm. The essential fuel properties can be found in Table 2. The engine was initially fuelled with diesel fuel to provide the baseline data and then, it was fuelled with biodiesel blend fuels. Before stopping the test engine after each test with biodiesel blend fuels, the engine was switched on diesel fuel until all the biodiesel based blend is purged from the fuel lines, injection pump and injector to avoid clogging when the engine is cooling down.

The performance test was carried out at 100% load keeping throttle 100% wide open using Dynomax-2000 software. The test procedure was carried out through DYNOMAX 2000 data control system. Engine performance data were measured at “Step RPM Test” mode (between 1500 and 2400 rpm with intervals of 100 rpm). The emissions of different pollutants were measured at 2200 rpm at 100% and 80% throttle position. A portable BOSCH exhaust gas analyzer (model ETT 0.08.36) was used to measure the hydrocarbon (HC) in part per million (ppm) whereas, carbon monoxide (CO) and carbon dioxide (CO2) were measured in percentage volume (%vol). NO_x emission was measured using AVL 4000 (Make: Graz/Austria) gas analyzer. In order to measure the sound level at different loads, the measurements of engine noise were taken from five directions at 1 meter away from the test engine bed such as front, rear, left, right and top side. However, in this work, only front side was selected, which produced the highest level of the noise. In this regard, to measure the noise level, NI Sound Level Measurement System was adopted. Therefore, PCB 130 Series of Array Microphones (microphone model 130D20) was employed in this work.

ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

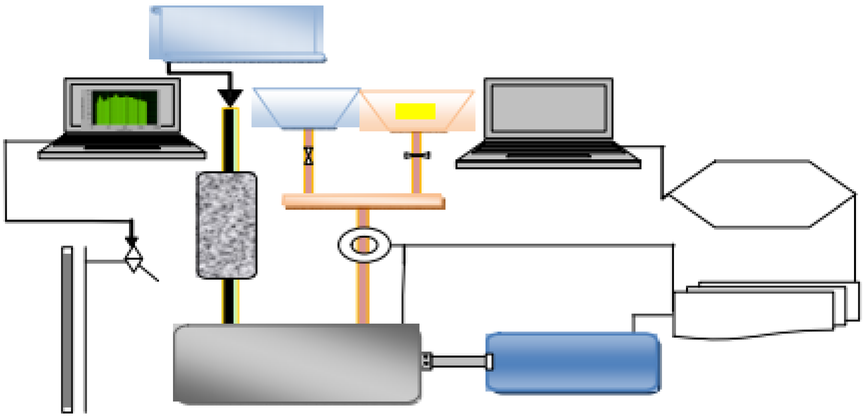


Figure 3 Schematic diagram of experimental setup

Table 1 Test engine technical specifications

Engine type		**Four stroke DI diesel engine**
Number of cylinders		One
Aspiration		Natural aspiration
Cylinder bore x stroke	mm	92 x 96
Displacement	L	0.638
Compression ratio		17.7
Max. engine speed	rpm	2400
Max. power	kW	7.7
Injection timing	deg.	bTDC 17.0
Injection pressure	kg/cm^2	200

Table 2. Some of the important tested fuel properties

Parameters	CB5	CB15	DF
Kinematic viscosity @ 40^0 C (cSt)	3.344	3.425	3.317
Heating value (MJ/kg)	45.407	44.838	45.547
Density @ 40^0 C (gm/cm3)	0.823	0.825	0.822
Flash point (^{0}C)	83	86	78
Cetane number	51.5	53.4	51

4.0 RESULTS:

Engine performance analysis

Torque

Figure 4(a) presents the effects of coconut biodiesel addition (% by volume) and net diesel fuel on the engine torque with respect to the engine speed. Keeping in view the engine torque results with biodiesel blends, it can be observed that the trend of this parameter as a function of speed for both biodiesel blends is almost found to be similar to net diesel fuel. Initially, engine torque increases as the engine speed increases until it reaches a maximum value and then starts decreases with further increasing engine speed. The engine torque reduction after certain speed is found to be due to the two main factors. Firstly, it is the lowered volumetric efficiency of the engine due to the increase in the corresponding engine speed, and the second one is the augmentations in the mechanical losses. For both biodiesel blends and diesel fuel, the maximum torque values were found at 2200 rpm of engine. However, net diesel fuel shows some higher torque values than biodiesel blends due to the fact that diesel fuel has

ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

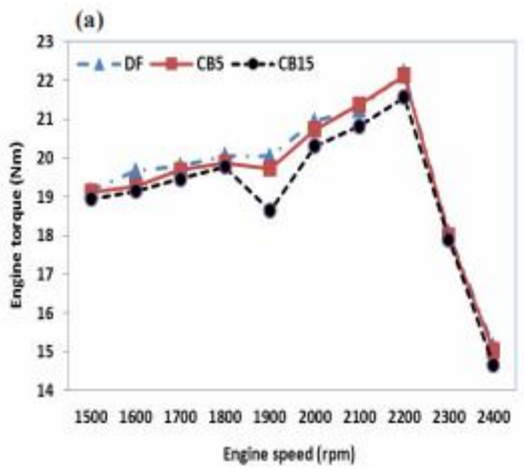
higher heating value than biodiesel blends. The average torque reduction compared to net diesel fuel is found as 0.69% for CB5 and 2.58% for CB15 respectively.

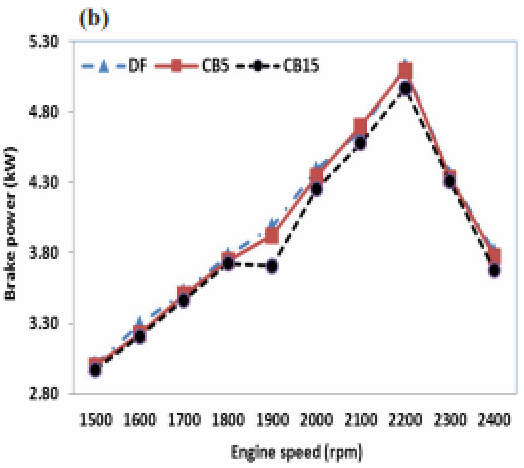
Brake power

Figure 4(b) illustrates the variations in the brake power for net diesel fuel and biodiesel blends as a function of the engine speed. It can be observed that brake power of the engine increases with increasing engine speed until 2200 rpm and then starts to decrease due to the effect of higher frictional force. The engine brake power for biodiesel blends was found to be lower than obtained for net diesel fuel. The lower brake power for CB5 and CB15 can be due to their respective lower heating values. The average power reduction compared to diesel fuel over the entire speed range is found as 0.66% for CB5 and 2.61% for CB10% respectively.

Brake specific fuel consumption

Figure 4(c) presents the brake specific fuel consumption (bsfc) for net diesel fuel and biodiesel blends as a function of engine speed. Good engine performance in terms of fuel economy is reflected by the bsfc parameter. For the biodiesel blends, heating value is found slightly higher than that for diesel fuel. This may be attributed to the lower heating value and higher density of the blends. It is also known that biodiesel contains oxygen content, which results in the lower heating value. Thus for the same energy output from the engine, it requires larger mass fuel flow, which increases bsfc to compensate the reduced chemical energy in the fuel. The average increase in bsfc compared to diesel fuel is found as 0.53% for CB5 and 2.11% for CB15 respectively





ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

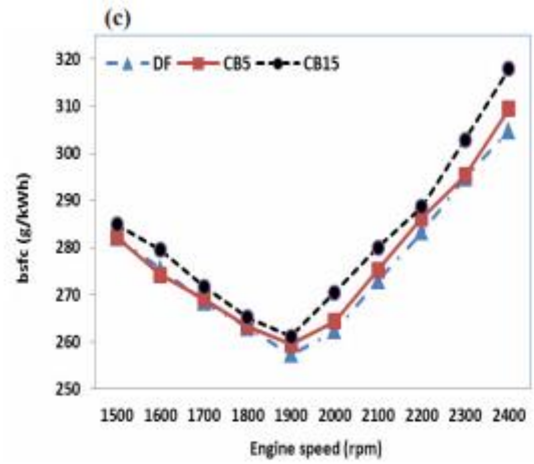


Fig. 4. Engine performance analysis.

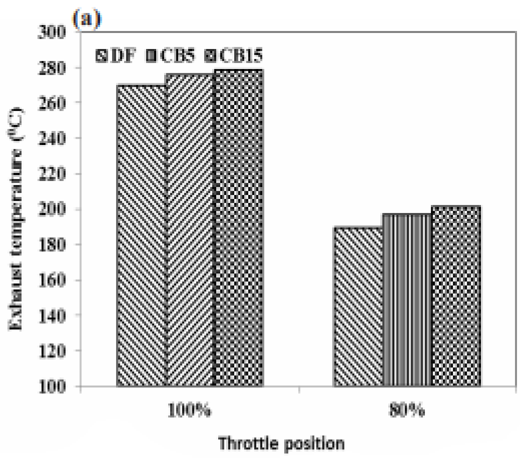
Exhaust emission analysis

Exhaust gas temperature

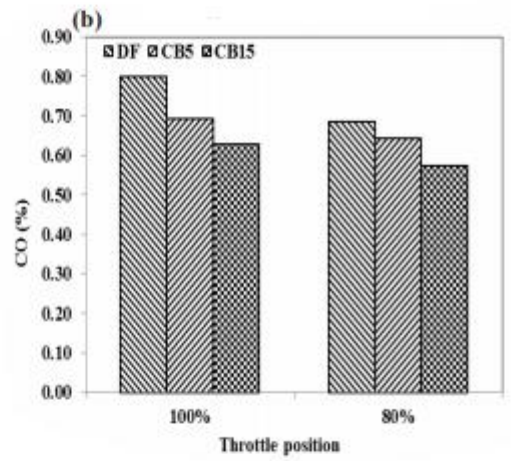
Figure 5(a) presents exhaust gas temperature at 2200 rpm at 100% and 80% throttle position for diesel fuel and biodiesel blends. In order to indicate the cylinder combustion temperature, engine exhaust temperature has been considered as one of the important parameters. Therefore, it is a good parameter in analyzing the exhaust emissions especially for NOx. The increase in exhaust gas temperature compared to diesel fuel at 2200 rpm and at 100% throttle position was observed as 2.22% for CB5 and 3.33% for CB15 whereas, at 80% throttle position, increase was found as 3.62 for CB5 and 5.96% for CB15 respectively.

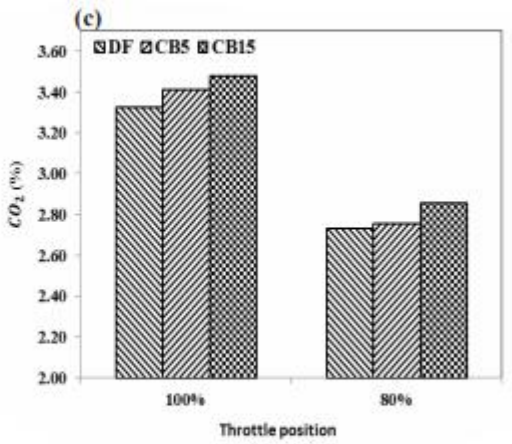
Carbon monoxide (CO) emission

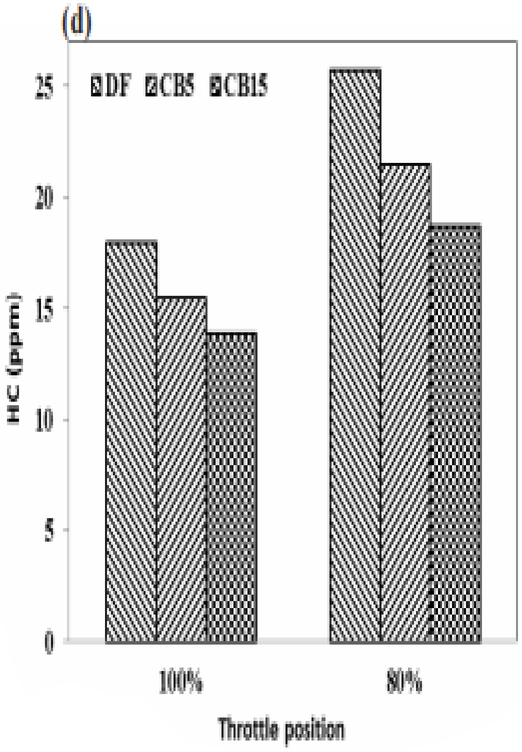
CO emissions at 2200 rpm, at 100% and 80% throttle position are presented in Fig. 3(b). CO is one of the compounds formed during the intermediate stages of fuels and is formed mainly due to incomplete combustion of fuels. If combustion proceeds to completion, CO is converted to CO2. If the combustion is incomplete due to shortage of air or low gas temperature, CO will be formed. In case of biodiesel blends, CO emissions were lower than that of diesel fuel, due to some extra oxygen contents, which convert CO to CO2 and resulted in complete combustion of the fuel. In another study, it has been reported that higher cetane munber of biodiesel blends; results in the lower possibility of formation of rich fuel zone and thus reduces CO emissions. Average reduction in CO at 2200 rpm and 100% throttle position was found as; 13.38% for CB5 and 21.51% for CB15, whereas, at 80% throttle position, reduction in CO was found as 5.98% for CB5 and 16.03% for CB15 respectively.



ISSN:0971-1260
Vol-22-Issue-4-October-December-2019







ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

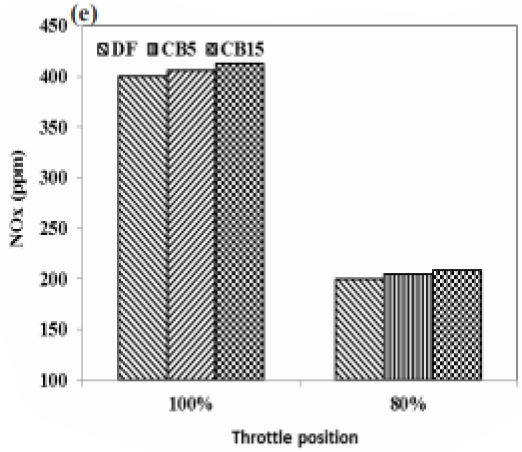


Fig. 5. Engine exhaust emission analysis.

Carbon dioxide (CO2) emission

Figure 5(c) illustrates the carbon dioxide (CO_2) emissions for diesel fuel and biodiesel blends at 2200 rpm at 100% and 80% throttle position. It can be noted that the CO_2 emissions for biodiesel blends increased compared to diesel fuel. This may be attributed to the oxygen content in biodiesel which reacts with unburned carbon atoms during the combustion and increases the formation of CO_2. More amount of CO_2 in exhaust emission indicates the complete combustion of fuel. Compared to diesel fuel, CO_2 for biodiesel blends at 2200 rpm and at 100% throttle position, was increased as 2.54% for CB5 and 4.64% for CB15 respectively. Whereas, at 2200 rpm at 80% throttle position, CO_2 compared to diesel fuel was increased as 0.79% and 4.56% respectively.

Hydrocarbon (HC) emission

HC emissions for diesel fuel and biodiesel blends at 2200 rpm at 100% and 80% throttle position are shown in Fig. 5(d). it has been reported that the oxygenated compounds available in the blends improve the fuel oxidation and thus it reduces HC emissions. When the oxygen content of fuel blend is increased, it requires less oxygen for combustion. However, oxygen content of fuel is the main reason for more complete combustion and HC emission reduction. Furthermore, higher cetane number of biodiesel blends reduces the combustion delay, and such a reduction has also been related to decreases in HC emissions. Compared to diesel fuel, reduction in HC at 2200 rpm and 100% throttle position was found as 13.89% for CB5 and 22.88% for CB15 respectively, whereas, at 80% throttle position, HC emission reduction was found as 16.58% CB5 and 27.19% for CB15 respectively.

Nitrogen oxide (NOx) emission

Figure 5(e) presents NOx emissions at 2200 rpm at 100% and 80% throttle position for diesel fuel and biodiesel blends. The NOx emissions for blends are found higher than diesel fuel. It has been reported that formation of NOx emissions are strongly dependent upon the equivalence ratio, oxygen concentration and burned gas temperature. Increased oxygen levels increase the maximum temperature during the combustion, and thus increase NOx formation. It is also agreed that in the production of NOx, the fuel borne oxygen is more effective than the external oxygen supplied with the air. The increase in NOx compared to diesel fuel at 2200 rpm and at 100% throttle position was observed as 1.42% for CB5 and 3.19% for CB15 whereas, at 80% throttle position, increase was found as 2.44 for CB5 and 4.64% for CB15 respectively.

Noise emission

As noise effects are restricted to the time of its emission, therefore, noise emission is thought to be quite different from that of air pollutants or other climate gases. The diesel engine

ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

produces much more noise than that produced by the spark ignition engine. The combustion noise is associated with the maximum pressure rise rate produced in the cylinder. Thus, higher pressure rise rate produces higher combustion noise and vice versa. It has been found that reduction in the ignition delay period results in reduction of the maximum pressure rise rate (dp/d), which leads to the smoother engine running. Thus shorter ignition delay reports for biodiesel and blends have been investigated by many authors. In our research work, sound level for diesel fuel and biodiesel blends was measured form five different directions (front, rear, left, right and top) around the test engine bed. However in this study as shown in Fig. 3, only front side has been selected which produced the highest level of the noise. Fig. 3 shows that the sound level for CB5 and CB15 is decreased as compared to diesel fuel and increased as the load (bmep) increased for each fuel sample. Lower sound level for biodiesel blends compared to diesel fuel may be attributed due to their higher viscosities which produced lubricity and damping and thus resulted in decrease of sound level. Secondly, higher cetane number of blend fuels may decrease the ignition delay which causes the maximum pressure rise rate to decrease so the engine produced lower sound level. Besides that, it was noted that engine noise emissions were reduced with the increase in fuel oxygen content in blend fuels due to improved combustion efficiency.

5.0 CONCLUSION:

This work presented the experimental investigations in terms of engine performance and emissions of using diesel fuel as baseline and biodiesel blends such as CB5 and CB15 respectively. Biodiesel, produced from renewable and often domestic sources, represents a more sustainable source of energy and will therefore play an increasingly significant role in providing the energy requirements for transportation. Therefore, more and more researches are focused on the biodiesel engine performances and its emissions in the past 10 years. Although there have always been inconsistent trends for biodiesel engine performances and its emissions due to the different tested engines, the different operating conditions or driving cycles, the different used biodiesel or reference diesel, the different measurement techniques or instruments, etc. Overall, biodiesel, especially for the blends with a small portion of biodiesel, is technically feasible as an alternative fuel in CI engines with no or minor modifications to engine. For environmental and economic reasons, their popularity may soon grow. However, more researches and development in biodiesel resources and engine design are needed. In this study, the Bio-diesel prepared from used vegetable oil was tested using a four stroke four cylinder diesel engine. The experimental results of this study showed that the brake power of bio- diesel is slightly higher than that of normal diesel for both medium and full throat. In addition Bio-diesel BSFC is higher than that of normal diesel for both full and medium throat all over the speed range. Also the bio-fuel has a lower thermal efficiency than the normal diesel. Regarding the emission characteristics of the, the normal diesel caused a higher burning gas temperature in the engine cylinder and consequently lowered the CO emissions compared to bio-diesel.

REFERENCES:

[1] Tesfa B, Mishra R, Gu, F, Ball AD. Water injection effects on the performance and emission characteristics of a CI engine operating with biodiesel. Renewable Energy 2012;37:333-344.

[2] Jindal S, Nandwana BP, Rathore NS, Vashistha V. Experimental investigation of the effect of compression ratio and injection pressure in a direct injection diesel engine running on Jatropha methyl ester. Applied Thermal Engineering 2010; 30: 442–448.

[3] Törnqvist M, Ehrenberg L. On cancer risk estimation of urban air pollution. Environmental health perspectives 1994;102(Suppl 4):173.

ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

[4] Iwai K, Adachi S, Takahashi M, Möller L, Udagawa T, Mizuno S, Sugawara I. Early Oxidative DNA Damages and Late Development of Lung Cancer in Diesel Exhaust-Exposed Rats. Environmental Research 2000;84(3):255-264.
[5] Dybdahl M, Risom L, Bornholdt J, Autrup H, Loft S, Wallin H. Inflammatory and genotoxic effects of diesel particles in vitro and in vivo. Mutation Research/Genetic Toxicology and Environmental Mutagenesis. 2004;562(1-2):119-131.
[6] Vincent R. Acute Cardiovascular Effects in Rats from Exposure to Urban Ambient Particles, STATEMENT: Synopsis of Research Report 104. Safe Environments Programme, EPA Grant Number: R828112C104, Environmental Protection Agency, 2003.
[7] Liaquat AM, Kalam MA, Masjuki HH, Jayed MH. Potential emissions reduction in road transport sector using biofuel in developing countries. Atmospheric Environment 2010;44(32):3869-3877.
[8] Hirkude JB, Padalkar AS. Performance and emission analysis of a compression ignition Engine operated on waste fried oil methyl esters. Applied Energy 2012;90: 68–72.