GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

PERFORMANCE ANALYSIS OF BIODIESEL BLEND IN DIESEL ENGINE- A REVIEW

Prof.P.M. Kadam [*1] & Prof. P.T. Kale[2]

[*1]Dept.of Mechanical Engg, Jspm's Imperial College of engineering and research, Pune

[2]Dept.of Mechanical Engg, Jspm's Imperial College of engineering and research, Pune

ABSTRACT

With Focus on reducing the Green House Gas emission, the use of biodiesel as an alternative fuel. In this study, the objective is to clarify the diesel-biodiesel blends on combustion, emission and performance characteristics of DI Engine.

Keywords- *DI Engine, biodiesel, jatropha curcus oil, biodiesel blends.*

I. INTRODUCTION

Unlimited use of fossil fuel has led to global environmental degradation and health hazards. Reduction in engine emission becomes a major task in engine development due to increasing concern of environment protection and more stringent emission norms. In addition to this more efforts are needed to reduce dependence on petroleum fuels as it obtained from limited reserves. It has been reported by the US department of energy that the world's oil supply will reach its maximum production and midpoint of deflection sometime around the year 2020. Legislation has been passed in many countries, requiring diesel to contain a minimum percentage of biodiesel. The Czech Republic proved to the best Which Insisted on 100% biodiesel use for transportation.

Diesel engine are widely used as power source in medium and heavy duty application because of their lower fuel consumption and lower emission of carbon monoxide (CO)and unburned hydrocarbon (HC) compared with gasoline engine. Rudolf diesel, the inventor of diesel engine, ran an engine on ground nut oil Paris Exposition of 1900, since then, vegetable oil have been used as fuels when petroleum supplies where expensive or difficult to obtain. With the increased availability of petroleum in the 1940's, research into vegetable oil decreased. Since the oil crisis of the 1970's research interest has expanded in the area of alternative fuels [1].

In case of using waste cooking oil in diesel engines, it is found to be an alternative way of reducing the disposal of waste cooking oil and for abatement of the fuel crisis as well. Waste edible oil (WEO) cannot be discharged into drain or sewers due to blockages and odors or vermin problems and many also pollute watercourse. It is also a prohibited substance and will cause problem if it is dumped bin municipal solids waste landfill and municipal sewage treatment plants, Being cheap and easily available, waste cooking oils seems like a good substance for diesel, but its high viscosity is a major drawback To overcome this problem, a small percentage, like 5% can be blended and tested for engine compatibility [2].

a) Advantages of Diesel Engine

Diesel engines have several advantages over other internal combustion engines

They burn less fuel than a petrol engine performing the same work, due to the engine's higher temperature of combustion and greater expansion ratio. Gasoline engines are typically 30% efficient while diesel engines can convert over 45% of the fuel energy into mechanical energy.

b) Disadvantages of Diesel Engine

The major disadvantages of the diesel engine are elevated NOx, particulate emissions, heavy weight, low specific power output, reduced engine speed and low exhaust gas temperature. The complex heterogeneous nature of diesel combustion leads to significant NO_x and particulate matter emissions from diesel engines. The basic disadvantage of diesel engine is that it is expensive. It expensive both in manufacturing and also in maintenance. It is expensive due to ecological incompatibility of its exhaust and due to necessity to adjust its exhaust according to strict requirements of international agreements [3].

c) Biodiesel as an Alternate Fuel

Biodiesel is a domestically produced, clean-burning, renewable substitute for petroleum diesel. Using biodiesel as a vehicle fuel increases energy security, improves public health and the environment, and provides safety benefits [4].

d) Energy Security and Balance

The United States imports about half of its petroleum, two-thirds of which is used to fuel vehicles in the form of gasoline and diesel. Depending heavily on foreign petroleum supplies puts the United States at risk for trade deficits, supply disruption, and price changes. Biodiesel can be produced in the U.S. and used in conventional diesel engines, directly substituting for or extending supplies of traditional petroleum diesel [5].

e) Engine Operation

Biodiesel improves fuel lubricity and raises the cetane number of the fuel. Diesel engines depend on the lubricity of the fuel to keep moving parts from wearing prematurely. One unintended side effect of the federal regulations, which have gradually reduced allowable fuel sulfur to only 15 ppm and lowered aromatics content, has been to reduce the lubricity of petroleum diesel. To address this, the ASTM D975 diesel fuel specification was modified to add a lubricity requirement (a maximum wear scar diameter on the high-frequency reciprocating rig [HFRR] test of 520 microns). Biodiesel can increase lubricity to diesel fuels at blend levels as low as 1%.Before using biodiesel, be sure to check your engine warranty to ensure that higher-level blends of this alternative fuel don't void or affect it. High-level biodiesel blends can also have a solvency effect in engines that previously used petroleum diesel.

f) Safety

Biodiesel is nontoxic. It causes far less damage than petroleum diesel if spilled or released to the environment. It is safer than petroleum diesel because it is less combustible. The flashpoint for biodiesel is higher than 130°C, compared with about 52°C for petroleum diesel.[6]

g) Jatropha Curcas Oil as a Biodiesel

Jatropha curcas is a large shrub native to the American tropics but commonly found and utilized throughout most of the tropical and subtropical regions of the world. Several properties of the plant, including its hardness, rapid growth, easy propagation and wide ranging usefulness have resulted in its spread far beyond its original distribution. The Jatropha oil is slow-drying oil which is odorless and colorless when fresh but becomes yellow on standing. The oil content of Jatropha seed ranges from 30 to 50% by weight and the kernel itself ranges from 45 to 60%. But the greatest difference between Jatropha oil and diesel oil is viscosity. The high viscosity of curcas oil may contribute to the formation of carbon deposits in the engines, incomplete fuel combustion and results in reducing the life of an engine. Biodiesel can be used directly as fuel for a diesel engine without having to modify the engine system. It has the major advantages of having high biodegradability, excellent lubricity and no sulfur content. Biodiesel is considered a promising alternative fuel for the reductions of pollution from diesel engines, boilers and other combustion equipments. Compared to fossil diesel fuel, biodiesel has several superior combustion characteristics. For example, when biodiesel is used as an engine fuel, approximately 11 % of oxygen content by weight in biodiesel may promote a more complete combustion and effectively reduce the production of unburned hydrocarbons and carbon monoxide. In addition, since biodiesel does not contain carcinogens such as polyaromatic hydrocarbons and nitrous poly-aromatic hydrocarbons, it produces pollutants that are less detrimental to human health when burned. Also, fuel characteristics of biodiesel are approximately the same as those of fossil diesel fuel.

II. LITERATURE REVIEW

a) Investigation of liaquata et al.

Liaquata et al. [7] has worked to analyze engine performance and emissions characteristics for diesel engine using different blend fuels without any engine modification.

A total of four fuel samples, such as DF (100% diesel fuel), JB(5%jatropha biodiesel and 95% DF), JB 10 (10%JB and 90%DF) and J5W5(5% JB waste cooking oils and 90% DF) respectively were used in this study. Engine performance test was carried out at 100% load keeping throttle 100% wide open with variable speeds of 1500 to 2400 rpm at an interval of 100 rpm. Whereas emission test were carried out at 2300 rpm at 100% and 80% throttle position As a result of investigation, the average torque reduction compared to DF for JB5,JB 10 and J5W5 was found as 0.63%,1.63% and 1.44% and average power reduction was found as 0.67%,1.66% and 1.54% respectively. Average increase in bsfc compared to DF was observed as 0.54%, 1.0%. JB 10 and 1.14 % for JB5, JB10 and J5W5 respectively. In case of engine exhaust gas emission, compared to DF average reduction in HC for JB 5,JB 10 and J5W5 at 2300 rpm and 100% throttle position found as 8.96%,11.25% and 12.50% where as at 2300 and 80% throttle position reduction was as 16.28%.30.23% and 31.98% respectively.

Liaquata et al. [7] investigated and concluded that by using DF (100%DF) a 100%throttle position found as 8.96 %, 11.25% and 12.50%.Using JB5 (5%jatropha biodiesel and 95 % DF) 80%

throttle position, reduction was as 16.28 %, 30.23% and 31.98% and J5W5 (5%JB, 5%Waste cooking oil and 90% DF) was found as 17.26%, 25.92% and 26.87% reduced of CO emission.

b) Investigation of Subramanian et al

Subramanian et al. [4] studied utilization of ethanol and biodiesel in automotive diesel engines in Indian perspective. This was done in view of environmental benefits, energy self sufficiency and boosting of the rural economy as well as measures related to implementation and barriers. In this study, scenario and policies of using biofuel in automotive engines in the Indian context has been discussed. The significant points emerged from the discussions are the feasibility as well as direct relevance of the biofuels for India, particularly for environmental reasons is clearly seen. This brief study covered short term laboratory investigations of a 20% biofuel blend (B20). A soybean methyl ester blended into diesel 20% by volume showed normal combustion performance comparable to that of diesel on a residential oil-fired boiler. No modifications to the combustion equipment were required. However, transient CO emissions at cold start increased when the test room and fuel temperature were gradually reduced to levels lower than 15^0C. The combustion of B20 biofuel blend exhibited similar gaseous emissions to those diesels, with the exception of SO_2. Nitrogen oxide emission from the biofuel and diesel were found to be similar found in this particular research. PM emission concentrations from biofuel were lower than diesel by 13%. Significant reduction in particle bound sulphate was also noted, by 12%, when compared with those from diesel. This indicates several potential benefits of using the biofuel blend in residential space, water heating and in industrial processes. The author elaborated the utilization of biodiesel and ethanol in automotive diesel engine.

Subramanian et al. [4] concluded that by using Gaseous emission of B20 blend a ± 2.5 % of oxides of sulphur and 13% PM are reduced and shows normal combustion performance as compared with neat diesel.

c) Investigation of Laforgia and Ardito

Laforgia and Ardito [8] experimentally investigated the overall performance, emission trends and combustion trends of indirect injection (IDI) engines. Pure biodiesel and blends of biodiesel combined with 10% methanol were used in the experiments. When the injection timing was advanced, better results were obtained, thus confirming the advantages of these fuels. The main conclusion of this investigation was that biodiesel could substitute the diesel fuel without substantial changes in the engine performance or modifying the engine itself. As for environmental protection, the replacement requires advancing the injection timing, in order to achieve pollution level lower than that of produced by the diesel fuel. This injection timing must be advanced 30% of the setting provided by the manufacturer to obtain best smoke results. Laforgia and Ardito studied the effect of injection timing advance on smoke and oxides of nitrogen. Based on the experiments carried out, the following conclusions were drawn by the investigators the biodiesel blend along 10 % methanol and neat diesel, a remarkable reduction of NO emerged from both the solution. and the injection must be advanced by 30% to obtain best smoke results, and same reduced oxides of nitrogen

d) Investigation of Carraretto et al.

Carraretto et al. [9] Carried out the potentialities of biodiesel as an alternative fuel based on strategic considerations and field experiences in boilers and diesel engines. The operations of a biodiesel fuelled boiler were also monitored for few months. The engines were bench-tested and then installed on urban buses for normal operation. Distances, fuel consumption and emissions (CO_2, CO, HC and NO_x) were also monitored in addition wear, tear, oil, air filters dirtiness and lubricant degradation were also monitored. Further investigations were devoted to assess some environmental aspects of biodiesel. In particular, the benefit of biodiesel to the total net emission of CO_2 during the whole life cycle was studied and the net energy requirement was evaluated. It was concluded that the biodiesel seems to be a promising solution for boilers, since only minor adjustments were required and performance characteristics were comparable with oil operation. Investigations were also carried out on internal combustion engines (ICE) using pure biodiesel and in blends with diesel fuel. Performance characteristics were slightly reduced while SFC was notably increased using biodiesel. CO emissions were observed to be reduced but NO_x increased. Preliminary tests showed that by optimizing the injection advance both performances and emissions can be improved. Due to the detergent properties, tanks have to be carefully cleaned before storage. The fuel is not compatible with some plastic materials used in pipes and gaskets resistant materials should be used (Viton or Teflon). In order to exploit some biodiesel peculiar characteristics, a careful study of the combustion dynamics should be performed. Author investigated the benefit of biodiesel to the total net emission of CO_2 during whole life cycle.

Carraretto et al. investigated and concluded using biodiesel blend along with 10% methanol and neat diesel, a remarkable reduction of smoke emerged from both solutions. and injection timing on smoke must be advanced by 30% to obtain best smoke results. Also advanced 30% injection timing of oxides of nitrogen, reduced the oxides of nitrogen.

e) Investigation of Nabi et al

Nabi et al. [10] carried work on combustion and exhaust emission with neat diesel fuel and diesel–biodiesel blends. In this research, biodiesel from non-edible neem oil was made by transesterification. Experiments were conducted with neat diesel fuel and diesel biodiesel blends in a four stroke naturally aspirated (NA), DI diesel engine. Compared with conventional diesel fuel, diesel biodiesel blends showed lower CO, and smoke emission but higher oxides of nitrogen (NO_x) emission. However, compared with the diesel fuel, NO_x emission with diesel biodiesel blends were slightly reduced when EGR was applied. Parameters studied by them are Carbon monoxide, Smoke, Oxides of nitrogen and concluded that biodiesel blends showed lower carbon monoxide, lower smoke, and higher oxides of nitrogen compared to neat diesel.

f) Investigation of Tat

The objective of Tat's [11] research was to determine the reason for the higher levels of NO_x emission that have been observed from biodiesel fueled engines. A concept map was developed to show the interrelationships between the fuel and engine variables that affect NO_x production. It was observed that a change in combustion timing caused by changes in fuel properties between diesel fuel and biodiesel might be the source of the NO_x increase. Tests were conducted to determine the effect of blending biodiesel with diesel fuel on these properties, and to determine the effect of biodiesel fuel properties such as the lower heating value, density, speed of sound, bulk modulus, cetane number, and volatility on the NO_x emission from a diesel engine fueled with biodiesel.

Author concluded that the difference in the fuel injection system would create differences in the injection characteristics, such as atomization and penetration rate, and this could have a role in NO_x emission of biodiesel. Tat also mentioned that neat biodiesel generally causes about 8% power loss while B20 causes about 2% loss. The transient cycle fuel consumption was about 13% worse with neat biodiesel.

Tats concluded that oxides of nitrogen were increased in the exhaust because of fuel properties were changed due to changed due to change in combustion timing. And Atomization and penetration rate were directly affected by difference in fuel injection system.

g) Investigation of Makareviciene et al

Makareviciene et al. [6] studied solubility of biodiesel fuel components in diesel, methanol, rapeseed oil methyl ester, ethanol, rapeseed oil ethyl ester systems. The solubility of components in the fossil diesel fuel ethanol rapeseed oil methyl ester system at 20^0C was substantially higher than in the fossil diesel fuel methanol rapeseed oil methyl ester system. The solubility of components in the fossil diesel fuel ethanol rapeseed oil ethyl ester system was slightly lower than in the fossil diesel fuel ethanol rapeseed oil methyl ester mixture. The moisture content of ethanol had a great influence on mixture solubility. With decrease of temperature, the solubility of components in the fossil diesel fuel ethanol rapeseed oil methyl ester system decreased. The objective of this research was to characterize the intersolubility of biodiesel fuel components in rapeseed methyl ester, rapeseed ethyl ester, ethanol, methanol and fossil diesel fuel and to use these results for multi component biodiesel fuel production. Based on the experiments carried out, the following conclusions were drawn by the investigator. Addition of ester to ethanol and fossil diesel increases intersolubility of ethanol and fossil diesel fuel. And Effect of moisture content on intersolubility of ethanol and biodiesel blend decreased intersolubility of biodiesel blend, and intersolubility of components of rapeseed oil methyl ester, ethanol, fossil fuel decreases with temperature, also concluded that methanol is not suitable for multi-component biodiesel production, due to its lower solubility.

h) 2.8 Investigation of Szybist et al

Szybist et al. [12] explored the efficacy of reducing the iodine value of soy-derived biodiesel fuels through increasing the methyl oleate (methyl ester of oleic acid) content and addition of cetane improvers, as strategies to combat the biodiesel NO_x effect. This was accomplished by spiking a conventional soy-derived biodiesel fuel with methyl oleate or with cetane improver. The impact on bulk modulus of compressibility, fuel injection timing, cetane number, combustion, and emissions were examined. The conventional B20 blend produced a NO_x increase of 3–5% relative to diesel, depending on injection timing. The bulk modulus of diesel was observed to be 2% lower than B20, yielding a shift in fuel injection timing of 0.1–0.3 (degrees) crank angle. The bulk modulus of the high methyl oleate B20 blend was observed to be 0.5% lower than B20, not enough to have a measurable impact on fuel injection timing. Increasing the methyl oleate portion of the biodiesel to 76% also had the effect of increasing the cetane number from 48.2 for conventional B20 to 50.4, but this effect is small compared to the increase to 53.5 achieved by adding 1000 ppm of 2-ethylhexyl nitrate (EHN) to B20. For the particular engine tested, NO_x emissions were found to be insensitive to ignition delay, maximum cylinder temperature, and maximum rate of heat release. The dominant effect on NO_x emissions was the timing of the combustion process, initiated by the start of injection, and propagated through the timing of maximum heat release rate and maximum temperature. A NO_x neutral B20 blend was demonstrated by altering the chemical composition of the biodiesel in order to reduce its iodine value. The reduction in the iodine value was accomplished by increasing the concentration of methyl oleate in the biodiesel. Increased levels of methyl oleate were effective at increasing the derived cetane number (DCN) of the biodiesel blends over a relatively narrow range. Further analysis showed that NO_x emissions as a whole were insensitive to DCN for this engine in the range investigated in this study.

Combustion analysis also revealed that NO_x emissions were insensitive to the maximum cylinder temperature and the maximum rate of heat release, but were sensitive to the timing or crank angle at which these maxima occurred. A more important factor in the engine-out NO_x emissions was an advance in the start of injection timing caused by the higher bulk modulus of compressibility of biodiesel fuels. This advance initiated a phase shift in the timing of the combustion process, as evidenced by the timing of the maximum heat release rate and the maximum cylinder temperature. The timing at which the maximum cylinder temperatures and heat release rates occurred proved to be more important than the magnitude of the maximum temperature and maximum heat release rate. This effect produced the most dominant trend in NO_x production throughout the fuel matrix examined. The NO_x-neutral behavior of the high methyl oleate B20 blend could not be explained by the shift in fuel injection timing because no measurable change was detected compared to conventional B20.

Szybist et al. [12] concluded that by reducing iodine value through increasing the methyl oleate reduces the biodiesel NO effect, and by increasing the cetane number reduce the biodiesel NO effect .Bulk modulus of elasticity shifts the injection timing by 0.1 to 0.3 crank angle for B20.For the particular engine tested NO emission is found to be insensitive to Ignition delay, maximum cylinder temperature and maximum rate of heat release.

i) Investigation of Baldassarri et al

Baldassarri et al. [13] evaluated the chemical and toxicological characteristics of emissions from an urban bus engine fueled with diesel and biodiesel blend. A turbocharged EURO-2 heavy-duty diesel engine operating in steady-state condition was used in experiments hydrocarbons were quantified. The effect of the fuels under study on the size distribution of particulate matter (PM) was also evaluated.

The use of biodiesel blend seems to result in small reductions of emissions of most of the aromatic and polyaromatic compounds these differences, however, have no statistical significance at 95% confidence level Author investigated the toxicological characteristics of emissions and size distribution of particulate matter.

Toxicological characteristics of emissions are most aromatic and polyaromatic compounds however have no statistical significance at 95% confidence level and Size distribution of particulate matter had no significant observed.

III. CONCLUSION

The observed emission, combustion and performance behavior of the fuels can be explained by the differences in the fuel properties, combustion characteristics and the impact of engine technology.

Long-term studies need to be conducted to determine engine performance over several reasons. Research on the long term chemical and thermal stability of the biodiesel blends need to be investigated as well. Future research will focus additional work on cold temperature performance of the blends and necessary modifications like retarding injection timing for reduction of oxides of nitrogen to allow for the safe and efficient use of these blends in cold climates. More laboratory experiments are considered necessary to confirm the preliminary data. Additional improvements in the engine performance and further reductions in the emissions can be realized along with the addition of exhaust after treatment systems should be the subject of further studies.

REFRENCES

1. The effect of biodiesel oxidation on engine performance and emissions,phD thesis , Monyem A ,lowa State University,1998.ss
2. Emission and Performance characteristics of an Indirect Ignition Diesel Engine fuelled with waste Cooking Oil.Energy, Kalam MA,Masjuki HH,Jayed MH,Liaquat AM 397-402,36,2011.
3. "Emissions and In cylinder Characteristics of Fischter-Tropsch and Conventional Diesel Fuels in Modern CI Engines". Sappok AG, Final Thesis to Massachusetts Institute of Technology. 1-165, 2006.
4. "Utilization of Liquid Biofuels In Automotive Diesel Engines: An Indian perspective", Subramanian kA, Singal SK, Saxena M, Singhal S, 29:65–72,Biomass and Bioenergy, 2005.
5. "Cetane Number Testing of Biodiesel. Report Data Base" Garpen JV,National Biodiesel Board, Jefferson City, Missouri: 65110, 1996.
6. "Solubility of Multi-Component Biodiesel Fuel Systems", Makareviciene V, Sendzikiene E, Janulis P, 96: 611–616 Bioresource Technology , 2005.
7. Center for Energy Science, Faculty for Energy Science,Faculty of Engineering,University of Malaya, A.M.Liquata, H.H.Masjukia, M.A.Kalama, M.Varmana M. A. Hazrata,M.Shabuddin ,M.Mofijur 50603 Kuala Lumpur,Malayasia.
8. "Biodiesel fueled IDI engines: Performances, Emissions and Heat Release Investigation, Laforgia D, Ardito V, 51: 53–59Bioresource Technology, 1994.
9. " Biodiesel as an Alternative Fuel: Experimental Analysis and Energetic Evaluations". Carraretto C, Macor A, Mirandola A, Stoppato A, Tonon S, Energy 29:2195-2211, 2004.
10. "Improvement of Engine Emissions with Conventional Diesel Fuel and Diesel–Biodiesel Blends", Nabi NM, Akhter SM, Shahadat ZM, 97(3): 372-378 Bioresource Technology, 2006.
11. "Investigation of Oxides of Nitrogen Emissions from Biodiesel-Fueled Engines". Tat ME, 1-147,Final Ph.D. report to Iowa State University:, 2003.
12. "Evaluation of Formulation Strategies to Eliminate the Biodiesel NOx Effect". Szybist JP, Boehman AL, Taylor JD, 86:1109-1126,McCormick RL,Fuel Processing Technology, 2005.
13. "Emission Comparison of Urban Bus Engine fueled with Diesel Oil and Biodiesel Blend". Baldassarri LT, Battistelli CL, Conti L, Crebelli R, Berardis BD, Iamiceli L, Gambino M, Iannaccone S , 327:147-162,Science of the Total environment 2004.