IJERST

International Journal of Engineering Research and Science & Technology

ISSN : 2319-5991
Vol. 3, No. 1
February 2014

www.ijerst.com

Email: editorijerst@gmail.com or editor@ijerst.com

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com
Vol. 3, No. 1, February 2014

Research Paper

A STUDY ON EFFECT OF OXYGENATED AND METALLO-ORGANIC FUEL ADDITIVE ON THE PERFORMANCE AND EMISSION CHARACTERISTICS OF DIESEL ENGINE

Alagu Sundara Pandian A[1]* and Paullinga Prakash R[1]

*Corresponding Author: **Alagu Sundara Pandian A** ✉ alagusundaram87@gmail.com

This article is a literature study of the effect of different fuel additives on performance and emission characteristics of CI Engine fuelled with additives of oxygenated and metallo-organic compounds. This study is based on the reports of researcher who published their findings. It was reported that the metal-based additives improved flash point, pour point and viscosity. Use of multi functional additives for diesel will lead better fuel conservation and emission. The emissions from diesel engines also seriously threaten the environment and are considered one of the major sources of air pollution. Investigations on reducing pollutants in particular particulate matter and nitrogen oxides are critical to human health, welfare and continued prosperity. The paper describes some properties of synthetic oxygenates and their influence on exhaust emissions from diesel engines. According to the results of examinations, oxygenates are an effective method for obtaining the reduction in the PM, CO and HC emissions.

Keywords: Oxygenates, Metal-Organic compounds, Emission, Additives

INTRODUCTION

Diesel engines though enjoying higher fuel economy than gasoline engines suffer from inherent higher PM and nitride oxide (NOx) emissions. Diesel-fuelled engines have the disadvantage of producing soot, particles and nitrogen oxides and are now subjected to increasingly severe legislation following revision of the standards by Auto oil. The required levels are difficult to achieve through engine design alone. Even with high-grade fuels, catalytic systems are being extensively investigated to remove particulates. But, there are still problems in the operation of these. There are many approaches to reduce particulate emission from trucks, by treatment systems (such as particulate traps) or by improving combustion processes. Before any of these approaches can be implemented, however, researchers need to fully understand all of the factors influencing the formation of particulate matters (PM) in exhaust gas emission including engine load, engine

[1] Veltech Multitech Dr. Rangarajan Dr. Sakunthala Engineering College, #42, Avadi Alamathi Road,Vellanur, Avadi, Chennai - 600 062.

speed, and air-fuel composition. Currently there are many techniques that are capable of improving the combustion processes of diesel engines, such as the fuel injection retarding, Exhaust Gas Recirculation (EGR), high pressure injection, and air intake supercharging. However, due to the trade-off between the PM and NOx emissions, it is very difficult to have simultaneous reductions of both. So the concept of additives are used. Generally oxygenated additives are used to improve the PM, HC Emission but it does not have any particular effect on NOx emission which is a serious threat to the Environment. So a new technology has emerged which leads to the use of metal- oxide compounds as additives.

EFFECT OF FUEL ADDITIVE ON THE PERFORMANCE OF DIESEL FUEL

Researches and scientist have used different additives to improve the performance of diesel fuel. A brief review of these fuel additives are placed here. Most of the researches have reported that the effect on the performance of additives depend upon the concentration of additives used in fuel. Researches analyze the effect of fuel additive based on various parameter such as

1. Particulate matter
2. Carbon emission
3. Specific fuel consumption
4. Brake Thermal Efficiency
5. NOx emission

Karas *et al.* (1998) investigated the effect of oxygenated additive of Commercial p - series glycol ether on diesel fuel. Two engines were used, they were 1990 Cummins L-10 heavy-duty diesel engine and 1991 Detroit Diesel Series 60 engine. The author found that there was a significant reduction in PC, HC and CO but there was a slight increase in NOx. In fact the HC emission was reduced upto 25% at 5% GE-C and 15% reduction in particulate emission in 1% GE-C. Raed Al-Hasanat *et al.* (2006) influenced the effect of anti smoking additive on diesel fuel. The research was conducted mainly considering the reduction in soot particles which was conducted on single cylinder engine. Metallo-organic additive was used with Ba 0,5% as base metal. This showed the decrease in soot particle by 50%. Satge´ de Caroa *et al* .(2000) presents the use of combination of additives and increase the efficiency of ethanol-diesel mix. The research was carried on two basis one on DI diesel engine and other on IDI diesel engine. Choosing an additive for ethanol fuel mix was difficult as ethanol has low cetane value. After much investigation two additives were chosen such as 1-octylamino-3-octyloxy-2-propanol N-octyl nitramine supplied by pure energy. Examination of the CO level with additive is reduced particularly at no load by 20% in DI Engine which is interesting for urban vehicles. But in IDI engines there was an overconsumption of diesel fuel by ethanol at 7% with additive. Jaromir Mares *et al* (2012) evaluated the effect of the additive ENVIROX on diesel engine. This additive is supplied by the company ENERGENICS. The test results are guarantee reduction of fuel consumption by 5-12%, improving the combustion, less smoke in current processes, reducing unburned hydrocarbons, and better economy. ENVIROX is an oxide of cerium (CeO_2). The test included two types of engines. Land Rover Engine LRD 300 TDi, made in 1996, and engine Tatra T3-930-31, made in 1990. The most significant decrease in fuel consumption reflected at the speed of 2000 min^{-1} and at 40% mpe load, were 10,87%. Considering soot emission The Land Rover Defender engine occurs in the presence of additive Envirox a significant decrease in smoke, almost 50%. In the case of Tatra engine, smoke was decreased by 83 %.Mukesh kumar Bunkar *et al.* (2012) evaluated the effect of using Methyl Tertiary Butyl Ether (MTBE) blended with diesel. It was investigated that the Brake Thermal Efficiency (BTE) of diesel engine using MTBE blends were decreased as the amount of blends increased in diesel. The BTE of diesel engine using 5% and 10% blends are 25.26% and 24.65%, respectively that it was less from 26.35% than that of diesel. The brake specific energy consumption of 5 and 10% of MTBE blends consumed higher energy in comparison to diesel fuel during tested on diesel engine. It was investigated that the brake specific fuel consumption of diesel engine using MTBE blends are increased for all brake load than that of diesel fuel. The fuel consumption of diesel fuel was higher when the MTBE blends are used 5% and 10%. As load is increased the FC is slightly increased in comparison to neat diesel. The FC of 5% and 10% consumed 5% and 10% more fuel as compared to conventional diesel fuel. Sharun Mendonca *et al.* (2013) performed an experiment to study the effect of dibutyl ether on diesel fuel and obtained that lower BSFC, NOx, HC was observed which was limited only up to a pressure of 250 bar beyond which there was increase in all parameters. Angela Leedham *et al.*, evaluated the effect of acid based lubricity and an ester based lubricity to study about the impact of metal contamination on injector. The results obtained were such that ester lubricity showed no effect on metal in diesel fuel while acid lubricity showed the deposition of zinc in injector. This was due to the corrosive effect of additive on the metal. Baskar *et al* (2011) investigated the effects of two oxygenates in diesel fuel. The additive that were chosen for investigation were Diphenyl ether and Diethelene glycol dimethyl ether. The tests were conducted on a Four stroke, naturally aspirated, water cooled, direct injection engine and the parameters were nitrogen oxides (NOx), total unburned hydrocarbon (HC), and carbon monoxide (CO). The engine tests were conducted at a constant engine speed of 2000 rpm. After stable operating conditions were experimentally achieved, the engines were subjected to similar loading conditions. Starting from no load the observations were recorded at 20%, 40%, 60% and 80%, all as percentages of the rated load .On testing there was a significant effect on the parameters. The test was further conducted for seeing the effect on smoke. There was about 50% reduction of opacity when blends DPE10 and DIGLYME10 are used and also 60% reduction when the blends DPE15 and DIGLYME15 were used. Both DPE and DIGLYME show almost the same effect as far as opacity is concerned. Mayan Kutty *et al.* (1995) experimented with a metal additive on a diesel power plant. The test was mainly done to study the effects of SO in emission of power plant, here the additive which was used was Mg based, the results found that in the case of MGOH the highest reduction was found to be 37% at 250 ppm Mg, and decreased to 31 and 27% at 150 and 100 ppm, respectively. With MGOA the decreases were 38.0, 33.5 and 25%. MGOB addition resulted in a reduction of SO_3 by 29%. Here the pH level was reduced t from 1% to 3.5%. The change was from acidic to slight neutral. Hanbey Hazar *et al.* (2011) studied the effect of methanol and organometallic additive on diesel fuel, an additive of dodecanol was added to prevent phase separation, additive used was MnO_2. First methanol was used in first trial and later MnO2 was used. It was found that the fuel containing methanol increased the SFC by 4.5% compared to diesel fuel at 5% addition, 8,8% in the 10% M+D fuel and 13% in the 15% M+D fuel. But in case of Mn the additive does not constitute a change in SFC. When the reference is compared with the diesel fuel, the 40 Mn additive in the rate of 2,4% and the 80 Mn additive in the rate of 3,9% have provided a reduction. Tartakovsky *et al* (2006) tested the effects of Motorsilk oil and diesel fuel additives on the emissions and fuel consumption of diesel engine. The results obtained were Oil additised by Motorsilk showed a reduction in SFC by 2-7% and by lubrisilk showed a improvement in fuel economy of 5-10% at 1500 rpm and 3-5% at 2300 rpm. NOx emissions reduction 13-30% at speed of 1500 rpm and 4-15% at speed of 2300 rpm. Reduction of PM concentrations: about 50-58% at speed of 1500 rpm, and about 25% at speed of 2300 rpm. The most pronounced reduction of NOx emissions was achieved after 30 hours of engine running-in with additized fuel: 13-30% at engine speed of 1500 rpm and 4-15% at engine speed of 2300 rpm. Oil additizing does not lead to any significant change in NOx emissions of the tested engine. Sathiyagnanam *et al* (2010) studied the effect of barrier coating and additive on diesel fuel. Here the engine components were coated with ZrO_2 /Al_2O_3 by using PSC technique and thickness of 150 microns and an organic additive of Di iso propyl ether was used. It was observed that there is a marginal difference in brake thermal efficiency between standard engine and thermal barrier coated engine. The brake thermal efficiency is increased by 3% from coated engine at maximum load when compared to standard engine. Smoke density increased for the thermal barrier coating plus fuel additive engine. 1.0% blend of fuel additive plus thermal barrier coating reduces smoke density to 15 HSU when compared to standard engine. Beyond part load 0.5%, 1.5% and 2.0% concentrations of the fuel additive, smoke density was slightly increased.

OXYGENATED FUEL ADDITIVE

Oxygenated fuel is nothing more than fuel that has a chemical compound containing oxygen. It is used to help fuel burn more efficiently and cut down on some types of atmospheric pollution. In many cases, it is credited with reducing the smog problem in major urban centers. It can also reduce deadly carbon monoxide emissions.

Oxygenated fuel works by allowing the gasoline in vehicles to burn more completely. Because more of the fuel is burning, there are fewer harmful chemicals released into the atmosphere. In addition to being cleaner burning, oxygenated fuel also helps to cut down on the amount of non-renewable fossil fuels consumed. Various additives used for oxygen enrichment of fuel are as below.

Among alcohol fuels, ethanol has good solubility, biodegradability, causticity and emissions performance, and is therefore more appropriate than methanol for a diesel engine. A merit of ethanol is that the oxygen content is as high as 34.8%, but it's disadvantageous cetane number is as low as merely eight and its viscosity as low as less than 1/3 of a diesel fuel. Additionally, the boiling point of ethanol is relatively low, and therefore its transportation and storage safety control should be treated the same as gasoline.

Methyl tert-butyl ether, also known as methyl tertiary butyl ether and MTBE, is an organic compound with molecular formula $(CH_3)_3COCH_3$. MTBE is a volatile, flammable, and colorless liquid that is sparingly soluble in water. It has a minty odor vaguely reminiscent of diethyl ether, leading to unpleasant taste and odor in water. MTBE is a gasoline additive, used as an oxygenate to raise the octane number. Its use is controversial in the US and declining in use in part because of its occurrence in groundwater and legislation favoring ethanol. However, worldwide production of MTBE has been constant at about 18 million tons/y (2005) owing to growth in Asian markets which are less subject to ethanol subsidies.

Dibutyl ether is a chemical compound belonging to the ether family with the molecular formula of $C_8H_{18}O$. It is colorless, volatile, and flammable liquid and has peculiar ethereal smell. Liquid dibutyl ether is lighter than water. On the other hand, the vapor is heavier than air. It is not soluble in water, but it is soluble in acetone and many other organic solvents. Due to this property, dibutyl ether is used as solvent in various chemical reactions and processes. For example, phenyllithium is commercially available as a Ca. 1.8 M solution in dibutyl ether. Because of the formation of peroxides, it should be protected from heat, light and air. Strong acids like HI and HBr can cleave this ether. In the presence of oxygen, dibutyl ether is oxidized to a peroxide or hydroperoxide.

Diphenyl ether is the organic compound with the formula $O(C_6H_5)_2$. The molecule is subject to reactions typical of other phenyl rings, including hydroxylation, nitration, halogenation, sulfonation, and Friedel-Craftsalkylation or acylation. This simple diaryl ether enjoys a variety of niche applications. It is synthesized by a modification of the Williamson ether synthesis, here the reaction of phenol and bromo benzene in the presence of base and a catalytic amount of copper. Several polybrominated diphenyl ethers (PBDEs) are useful flame retardants. Of penta-, octa-, and decaBDE, the three most common PBDEs, only decaBDE is still in widespread use since its ban in the European Union in 2003.

Diethelene glycol dimethyl ether is a colorless liquid with characteristic odor. The vapor is heavier than air and may travel along the ground; distant ignition possible. The substance can readily form explosive peroxides. Reacts violently with strong oxidants. The substance can be absorbed into the body by ingestion, by inhalation and through the skin. The bp and mp is 82-83°C and -58°C and its auto ignition temperature is 202°C. No indication can be given about the rate at which a harmful concentration of this substance in the air is reached on evaporation at 20°C.

EXPERIMENTAL SET-UP

The experimental set up for testing the effect of oxygenated additive is shown in Figure 1. Its technical specifications as follows:

Figure 1: Experimental Setup

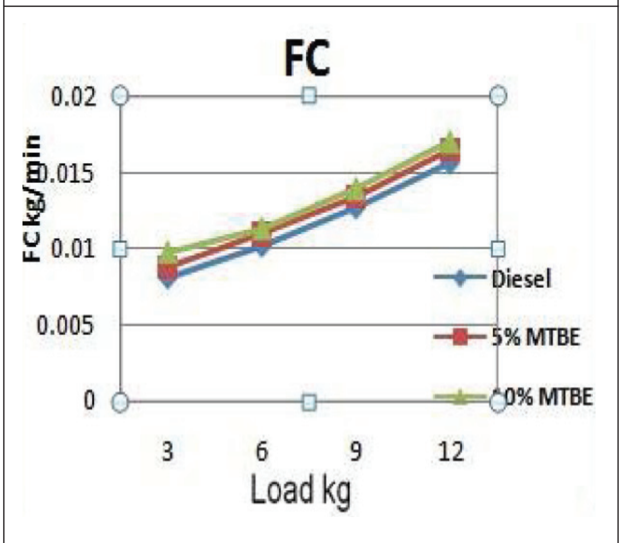
Company and Model	Kirloskar oil Engine SV1
Type	Single cylinder, 4- Stroke, diesel engine
Bore	87.5 mm
Stroke	110 mm
Rpm	1500 rpm
Rated power	8 HP
Type of cooling	Water cooled
Compression ratio	16.5:1

EFFECT OF OXYGENATED FUEL ADDITIVE ON THE PERFORMANCE AND EMISSION CHARACTERISTICS OF THE ENGINE

Fuel Consumption (FC)

Figure 2 shows the Variation of fuel consumption for neat Diesel, 5 and 10% blends of MTBE. It was resulted that the fuel consumption of diesel fuel is higher when the MTBE blends are used 5% and 10%. As load is increased the FC is slightly increased in comparison to neat diesel. The FC of 5% and 10% consumed 5% and 10% more fuel as compared to conventional diesel fuel.

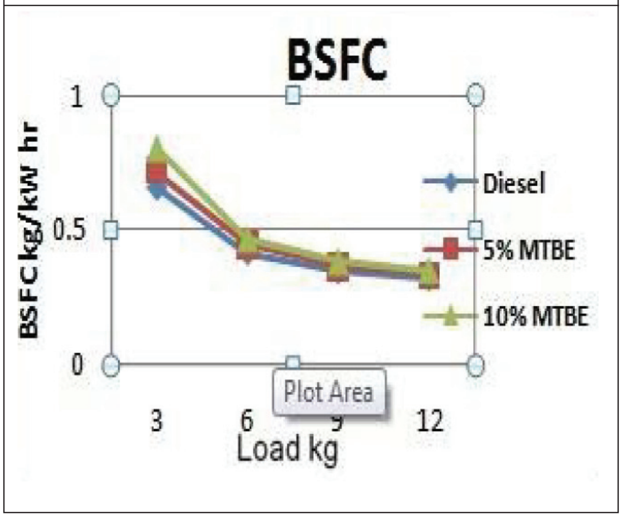
Figure 2: Variation of Fuel Consumption with Load



Brake Specific Fuel Consumption

Figure 3 shows the Variation of brake specific fuel consumption for Diesel, 5% and 10% MTBE blends. The brake specific fuel consumption is an essential parameter to compare engines and determine of fuel efficiency of an engine. It was resulted that the BSFC is higher than the diesel fuel when the MTBE blends are used 5% and 10%. The BSFC slightly decreased with increased the load. The BSFC of 5% and 10% consumed approximately 4% and 7% more fuel than that of diesel fuel.

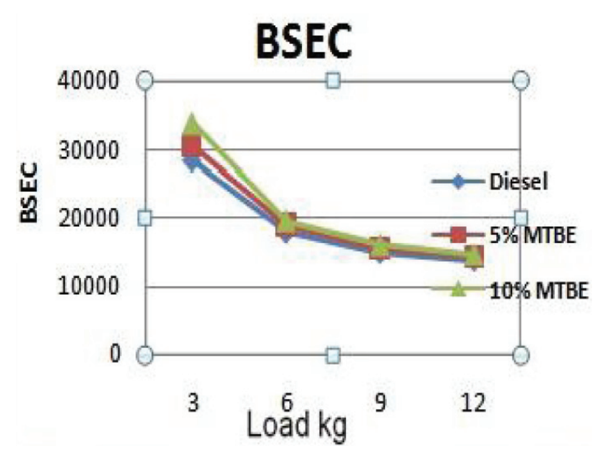
Figure 3: Variation of Brake Specific Fuel Consumption with Load



Brake Specific Energy Consumption

Figure 4 shows the variation of brake specific energy consumption for Diesel, -5% and 10% MTBE blends. It was resulted that the brake specific energy consumption is higher than that of diesel fuel when the MTBE blends are used 5% and 10%. The BSEC slightly decreased with increased the load. The BSEC of 5% and 10% consumed 5.34% and 9% more as compared to diesel fuel.

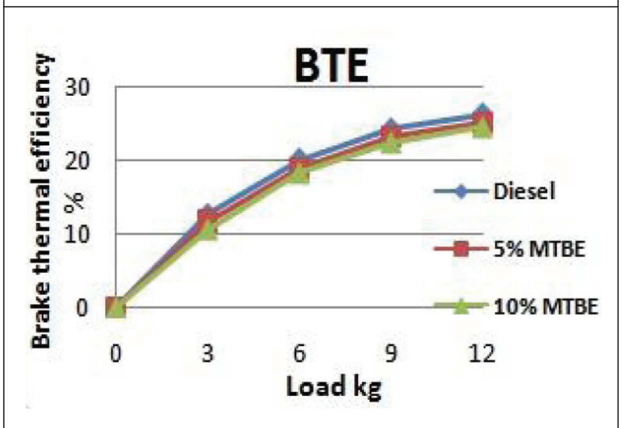
Figure 4: Variation of Brake Specific Energy Consumption with Load



Brake Thermal Efficiency

Figure 5 shows the variation of BTE for 5% and 10% MTBE blends. It is investigated that when the 5% and 10% MTBE blends are used in diesel engine decreased brake thermal efficiency approximately 4-7% than that of diesel fuel. The result showed of 10% MTBE blend the poor thermal efficiency in comparison to neat diesel and 5 % blends.

Figure 5: Variation of Brake Thermal Energy with Load



METALLO-ORGANIC ADDITIVE

Metallo-organic additive are those which are synthesized as a combination of an organic compound containing a base metal. The main concept of using these type of additive because the use of only organic additive has no serious effect on NOx emission and the other parameters also improve on using this additive. Some of them are

Barium oxide, BaO, is a white hygroscopic compound formed by the burning of barium in oxygen, although it is often formed through the decomposition of other barium salts. It reacts with water to form barium hydroxide. It readily oxidizes to BaO_{1+x} by formation of a peroxideion. The complete peroxidation of BaO to BaO_2 occurs at moderate temperatures but the increased entropy of the O_2 molecule at high temperatures means that BaO_2 decomposes to O_2 and BaO at 1175K

Envirox is a chemical preparation based on cerium oxide (CeO_2), which when added to fuel acts as a catalyst. Does combustion processes so that substantially reduces harmful combustion, unburned fuel and particulate matter in exhaust gases. It allows almost complete combustion of hydrocarbons without the formation of soot. The Envirox additive enables to obtain more energy from fuel and to reduce its consumption, remove the rest of soot deposits in the engine combustion and while minimizing the creation of some contaminants.

MgO and $Mg(OH)_2$ are also used as additives for diesel fuel, which are generally available in oil dispersed forms. Oil-soluble, organometallic additives based on Mg or Mg-Mn combinations are also being used quite successfully. In cases where the primary aim of the fuel additive is to achieve improved fuel combustion, additives based on a combination of metals including Mg, Mn and some transition metals are used quite effectively. To reduce back-end corrosion use of MgO either as powder or in suspended form has been reported to be effective if injected in the convective passes where most of the SO_3 is formed catalytically. MgO inhibits the catalysis of SO_2 to SO_3 by oxides of vanadium and iron. It also reacts with V_2O_5 and Na_2SO_4 to form high-melting compounds such as magnesium vanadates and sodium magnesium vanadates. As the melting points of the new products are much higher than the metal temperature normally encountered, metal loss due to high temperature corrosion resulting from the presence of molten compounds such as Na_2SO_4 and V_2O_5 on the furnace surfaces are greatly reduced. MgO, in addition to inhibiting the formation of SO_3, also effectively neutralizes the acid that condenses on the cooler parts of the air heating system, forming neutral $MgSO_4$.

CONCLUSION

Various oxygenated fuel additives are available which posses more oxygen content compared to diesel. If these additives are added in diesel at appropriate proportion it will improve the engine performance and emission characteristics. If the proportion of these additives is more than engine performance declines because the additives have lower calorific value compared to diesel. Other barriers in the use of oxygenated fuel additives are their high price and poor availability. To overcome these difficulties metallo-organic additives are used which improve the performance parameter of diesel fuel and also reduce NOx to a particular extent.

REFERENCES

1. Angela Leedham and Rinaldo Caprotti (2004), " Impact of Fuel Additives on Diesel Injector Deposits".
2. Aromir Mares J, Frantisek Bozek, Zbysek Korecki and Petr Krizek (2012), "Properties Verification of the Fuel Additive Envirox".
3. Baskar P, Nanthagopal K and Elango T (2011), "The Effect Of Two Oxygenates On Diesel Engine Emissions".
4. Hanbey Hazar and Lker Temizer (2011), " The Research Of The Effect Of Fuel Additives On Engine Oil And Engine Parts".
5. Irshad Ahmed (2001), " Emissions and Performance Characteristics of Ethanol-Diesel Blends in CI Engines".
6. Karas L J, Kesling H S, Jr., Liotta F J, Jr., and Nandi M K (1998), "Low Emission Oxygenated Diesel Fuel".
7. Mayan Kutty P C and Abdul Ghani Dalvi (1995), "Evaluation Of Chemical Fuel Additives To Control Corrosion And Emissions In Diesel Powe Plant".
8. Mukesh kumar Bunkar, Nitin Shrivastava and Vipin Shrivastava (2012), "Experimental Investigation of Diesel Engine On Methyl Tertiary Butyl Ether".
9. Raed Al-Hasanat (2006), " The Influence of Antismoking Additives on Exhaust Gases of Diesel Engine".
10. Satge´ de Caroa P, Moulounguia Z, Vaitilingomb G and Bergec J Ch. (2000), " Interest of combining an additive for use in diesel engines".
11. Sathiyagnanam A P, Saravanan C G and Dhandapani S (2010), "Effect of Thermal-Barrier Coating plus Fuel Additive for Diesel Engine".
12. Sharun Mendonca and John Paul Vas (2013), "Effect of Oxygenated Fuel Dibutyl Ether on Diesel Engine".

13. Tartakovsky L, Veinblat M, Baybikov V, Gutman M and Zvirin Y (2006), "Effects of Motorsilk Oil and Fuel Additives on Fuel Consumption and Emissions of Diesel Engine".

International Journal of Engineering Research and Science & Technology
Hyderabad, INDIA. Ph: +91-09441351700, 09059645577
E-mail: editorijlerst@gmail.com or editor@ijerst.com
Website: www.ijerst.com

ISSN 2319-5991