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Research Article

Effect of adding Triacetin additive with Coconut oil methyl ester (COME) in performance and emission characteristics of DI diesel engine

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Abstract

With the usage of diesel fuel and neat bio-diesel to some extent knocking can be detected in all the engines. Triacetin [C9H14O6] is a good anti-knocking additive and easily soluble in biodiesel. The usage of T- additive suppressed knocking, improved the performance and reduced tail pipe emissions. Comparative study was conducted using petro-diesel, bio-diesel, and with various additive blends of bio-diesel on DI- diesel engine. Coconut oil methyl ester (COME) is used with triacetin (T) at various percentages by volume for all loads (No load, 25%, 50%, 75% and full load). The performance of engine is compared with neat diesel in respect of engine efficiency, exhaust emissions and combustion knock. Of the five Triacetin-biodiesel blends tried, 10% Triacetin combination with biodiesel proved encouraging in the performance of engine in all aspects.

Keywords: *Additive, Biodiesel, Performance, COME, Exhaust emissions, Triacetin*

1. Introduction

Around the world, there is a growing increase in biofuels consumption, mainly ethanol and biodiesel as well as their blends with diesel that reduce the cost impact of biofuels while retaining some advantages of the biofuels. This increase is due to several factors like decreasing the dependence on imported petroleum; providing a market for the excess production of vegetable oils and animal fats; using renewable and biodegradable fuels; reducing global warming due to its closed carbon cycle by CO_2 recycling; increasing lubricity; and reducing substantially the exhaust emissions of carbon monoxide, unburned hydrocarbons and particulate emissions from diesel engines. However, there are major drawbacks in the use of biofuels blends as NOx tends to be higher, the intervals of motor parts replacement such as fuel filters are reduced and degradation by chronic exposure of varnish deposits in fuel tanks and fuel lines, paint, concrete, and paving occurs as some materials are incompatible. Here, fuel additives become indispensable tools not only to decrease these drawbacks but also to produce specified products that meet international and regional standards like EN 14214, ASTM D 6751, and DIN EN 14214, allowing the fuels trade to take place. Additives improve ignition and combustion efficiency, stabilize fuel mixtures, protect the motor from abrasion and wax deposition and reduce pollutant emissions, among other features. Two basic trends are becoming more relevant: the progressive reduction of sulfur content and the increased use of biofuels. Several additives compositions may be used as long as they keep the basic chemical functions that are active.

Emissions from diesel engines seriously threaten the environment and are considered one of the major sources of air pollution. It was proved that these pollutants cause impacts in the ecological systems, lead to environmental problems, and carry carcinogenic components that significantly endanger the health of human beings. They can cause serious health problems, especially respiratory and cardiovascular problems. Increasing worldwide concern about combustion-related pollutants, such as particulate matter (PM), oxides of nitrogen (NOx), carbon monoxide (CO), total hydrocarbons (THC), acid rain, photochemical smog and depletion of the ozone layer has led several countries to regulate emissions and give directives for implementation and compliance. It is commonly accepted that clean combustion of diesel engines can be fulfilled only if engine development is coupled with diesel fuel reformulation or additive introduction. (Ulrich et al, 2003**)** In this way, methods to reduce PM and the present work was under taken to study the performance of D I diesel engine with coconut oil methyl ester and triacetin additive blends at different percentages. Normally additives are used to boost the combustion hence improves fuel economy at lower emission rates.

NOx emissions include high-pressure injection, turbo charging, and exhaust after treatments or the use of fuel additives, which is thought to be one of the most

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attractive solutions. **(**Yanfeng et al, 2007**)** Engine exhaust contains volatile organic compounds (VOCs), which embody unburned fuel emissions and other VOCs generated as byproducts of incomplete combustion (PIC). Some VOCs described as being of health concern are acetaldehyde, acrolein, benzene, 1, 3-butadiene, formaldehyde, and naphthalene. Gasoline- and diesel-powered vehicles are the largest source of VOCs in most urban areas **(**Pereira et al, 2002**).** Diesel oil is a fuel derived from petroleum and consists mainly of aliphatic hydrocarbons containing 8-28 carbon atoms with boiling points in the range of 130-370 °C. It is a blend of fractions of hydrocarbons heavier than those of the hydrocarbons in gasoline and with a lower H/C mass ratio, which determines the high emission of carbon compounds per unit of energy delivered to the engine. A reduction in consumption and improvements in the quality of diesel oil have been the object of study by various specialists, motivated by growing demands in the transport and electric sectors.

Commercially available diesel oil is a combination of fossil diesel and several additives, which are added in several amounts to perform specific functions. Among others, there are additives to (1) reduce pernicious emissions; (2) improve fluid stability over a wider range of conditions; (3) improve the viscosity index, reducing the rate of viscosity change with temperature; (4) improve ignition by reducing its delay time, flash point, and so forth; and (5) reduce wear with agents that adsorb onto metal surfaces and sacrificially provide chemical-to-chemical contact rather than metal-to-metal contact under high-load conditions. There is also an increasing trend to use blends with biomass products such as vegetable oil, ethanol, and biodiesel by increasing the use of alternative fuels. Blends of diesel and biodiesel usually require additives to improve the lubricity, stability, and combustion efficiency by increasing the Cetane number.

Blends of diesel and ethanol (E-diesel) usually require additives to improve miscibility and reduce knock. Diesel additives can also be classified according to the purpose for which they are designed. Preflame additives are designed to rectify problems that occur prior to burning and include dispersants, pour point depressants, and emulsifiers, which act as cleaning agents. Flame additives are used to improve combustion efficiency in the combustion chamber, to increase cetane number, to reduce the formation of carbon deposits, to avoid oxidation reactions and contamination of fuel and filters clogging by rust, and to inhibit potential explosions caused by changes in static electricity **(**Chao et al, 2000**).**

Postflame additives are designed to reduce carbon deposits in the engine, smoke, and emissions **(**Yang et al, 1998**).** Due to the worldwide effort to make renewable energy economically viable as well as to use cleaner fuels, additives will become an indispensable tool in global trade. Their technical specifications not only cover a wide range of subjects but also most subjects are interdependent. This makes the expertise of additives technology indispensable in the global trade of fuels. It is likely that, as energy sources become cleaner and renewable, we might find ourselves facing issues that are quite hard to overcome, and diesel additives may become a worldwide indispensable tool. The additives share in the world market should increase in the next few years as long as energy sources become cleaner and renewable.

The DI diesel engine test rig details are shown in table 1and fig.1 with various equipment modules. Experiments were conducted with neat diesel, pure COME and COME with triacetin additive at different percentages for full load range of the engine. During test the performance, exhaust emissions and smoke density parameters and cylinder vibration were measured by using indicated instruments.

2. Experimentation

Cylinder combustion pressures for each degree of crank angle were measured by engine data logger designed by Apex innovations, Pune, India. The software employed is C7112, which captures the combustion pressure data and converts it into the graphic form collecting crank angle history from the encoder and synthesizes with the real time pressure data.

Fuel consumption was measured to calculate BSFC, fuel air ratio and thermal efficiency. Exhaust temperatures were also recorded for all loads. Delta 1600-L exhaust gas analyzer(German Make) was used to measure CO2, CO, HC, NO in exhaust gases at all loads and compared with graphs. DC-11(E-Predict, Canada) Vibration analyzer was employed to measure the engine cylinder vibrations in all three directions. The FFT curves generated have been used to evaluate the combustion propensity at different loads and with the alternative fuel. This measurement is better way to assess the knocking of the engine.

Table 1 Specifications of engine test rig

Engine manufacturer-Kirloskar Oil Engines Limited, India	
Engine type	Vertical, 4stroke, Single cylinder, DI
Cooling	Water cooled
Dynamometer	Eddy current dynamometer
Rated power	3.7 kw @ 1500 rpm
Bore/Stroke	80/110 (mm)
Compression Ratio	16.5:1
Injection pressure	200kg/cm2
Injection timing	23^0 BTDC

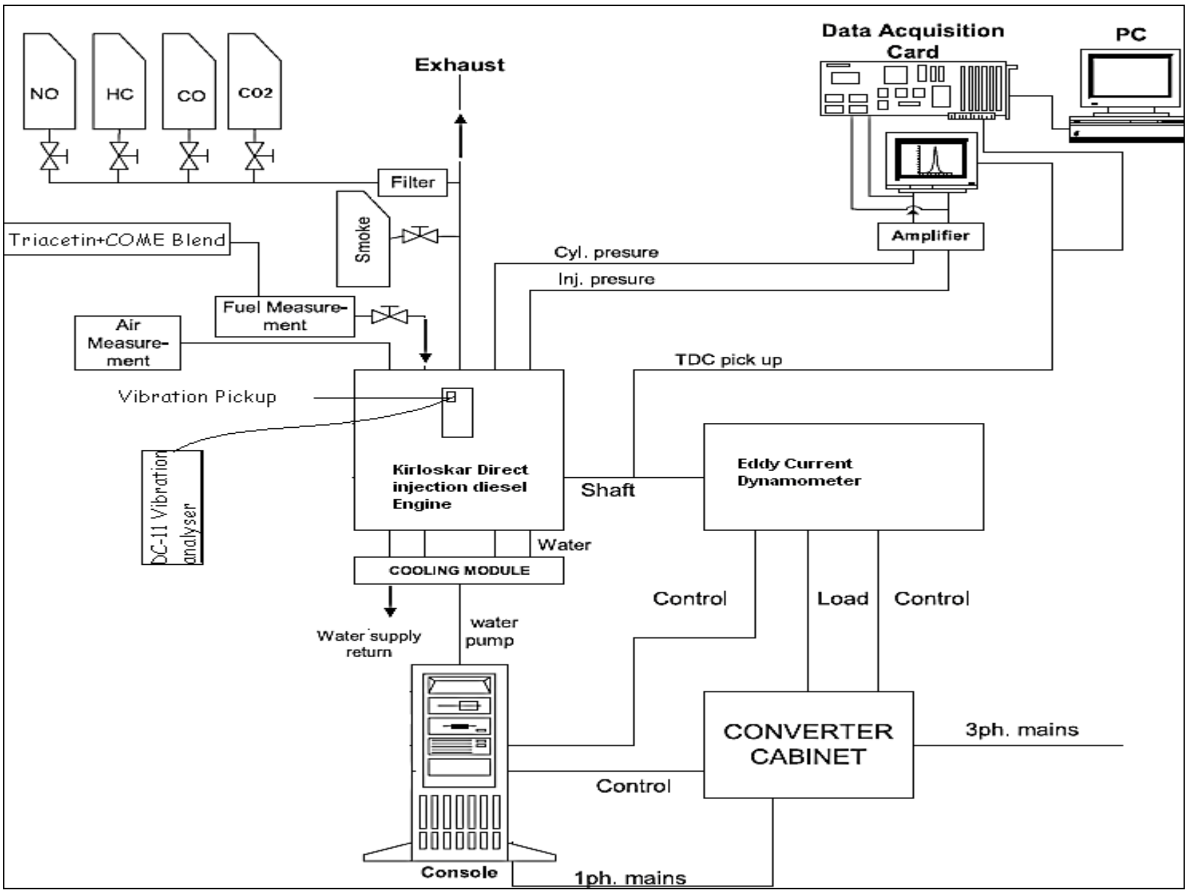

Fig.1 Schematic Diagram representing of the engine and instrumentation

4. Results and discussion

The performance and emission parameters were measured for diesel, COME and COME with triacetin additive blends without modifications in the engine.

- From figure (2) it can be ascertained from the figure that the equivalence ratio is increasing with the Triacetin additive percentage. This is because of lower calorific value of the additive compared to the main biodiesel. The maximum equivalence ratio difference observed is nearly 0.15 when Triacetin is being added. The 10% triacetin blend yielded better thermal efficiency curve at higher loads.
- The figure (3) envisages that for 10% triacetin blend, the part load performance is observed better corroborating with the brake thermal efficiency described above.
- There is marginal fall (figure 4) in the exhaust gas temperatures with respect to increase in the load on engine by using higher percentages of Triacetin and this may be because of lower heat release rate in the diffused combustion of lower calorific value of the blended fuel.
- There is 75% maximum reduction in HC emission with the triacetin blending as observed from figure (5)
- As the load on the engine increases, the HC emission decreases at all percentages of blends tested
- NO emission decreases with the load on the engine and especially more decrease can be observed at three fourth of full load. Nearly 28 to 29% maximum decrease in this emission can be observed with the Triacetin blend from figure (6).
- Carbon monoxide (CO) emission also reduced by 50% [maximum] as from figure (7) and trade off with other emissions has not been observed.
- Carbon Dioxide (CO2) emission reduces by nearly 10% with the blends and at higher loads.
- Engine smoke levels have decreased substantially with additive application as in figure (9).
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10% Triacetin [$C_9H_{14}O_6$] **blend** with bio-diesel is the most economical one in reducing emissions as can be observed from the figures from 5 to 9 in which absolute values of diesel against the reduction/ increase by percent for blends have been shown. Triacetin blend with the bio-diesel has decreased both the HC and NO emissions. NO emission decrease is most important with the additive mixing and it may be because of lesser hydrocarbon availability with the dilution of Triacetin and the comparative rarity of fuel elements reduces the combustion temperatures.

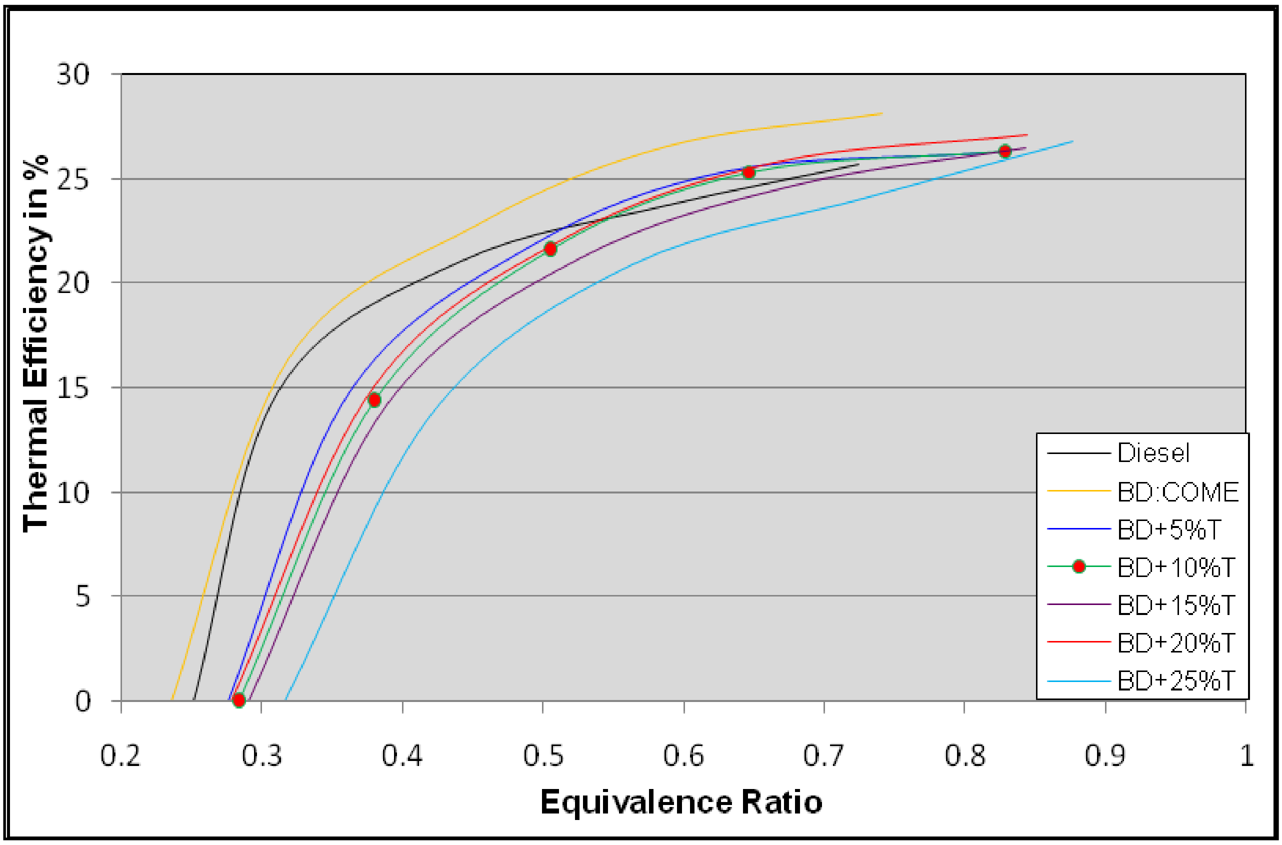

Fig.2 Variation of brake thermal efficiency verses load on engine

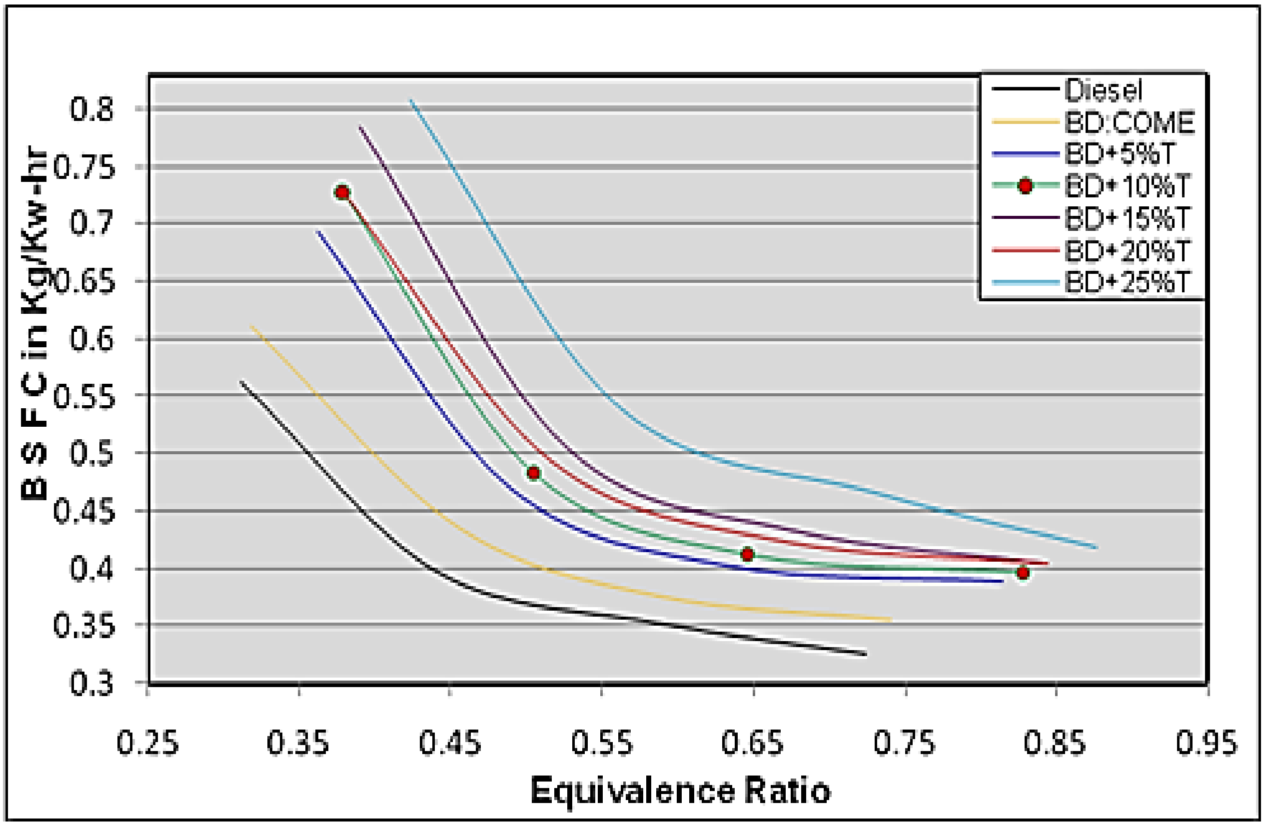

Fig.3 Variation of bsfc verses equivalence ratio of engine

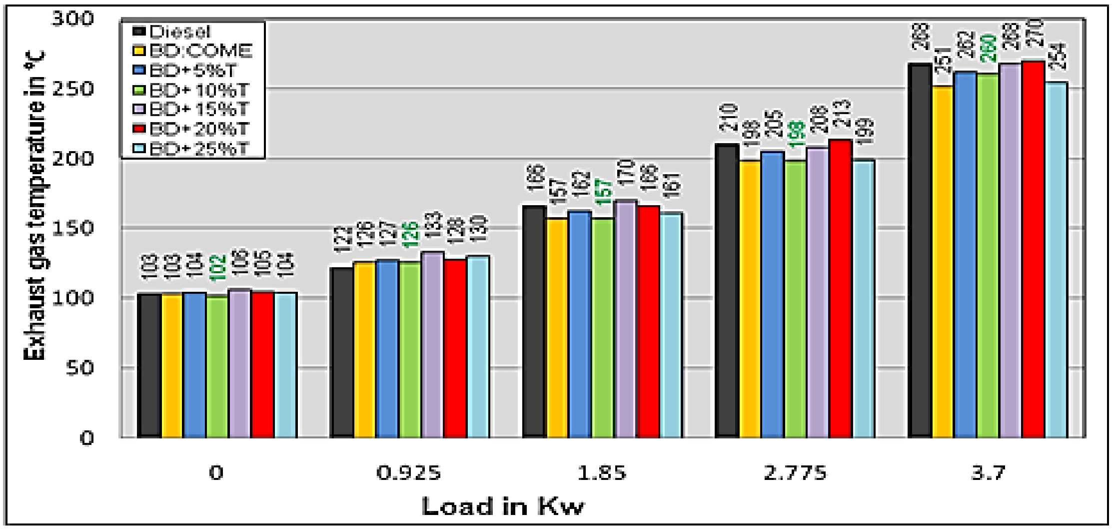

Fig.4 Variation of exhaust gas temperature verses load on engine

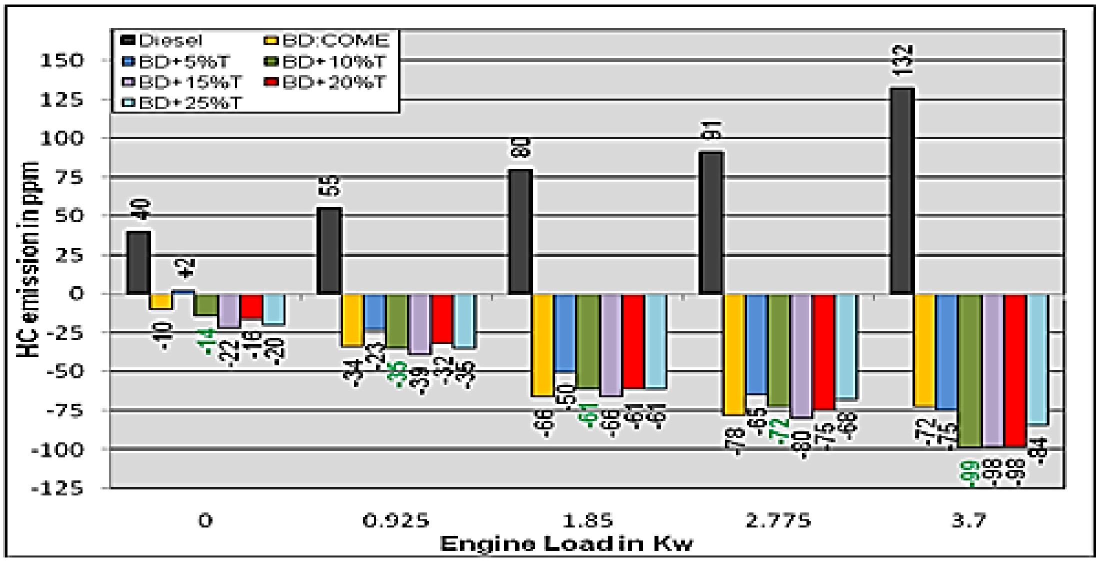

Fig.5 Variation of hydrocarbon emission verses load on engine

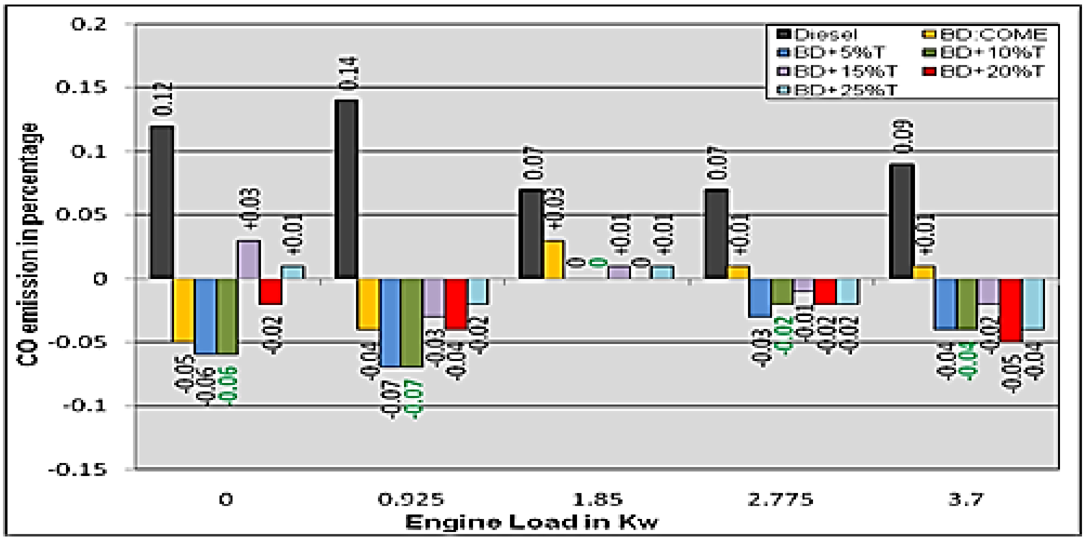

Fig.6 Variation of carbon monoxide emission verses load on engine

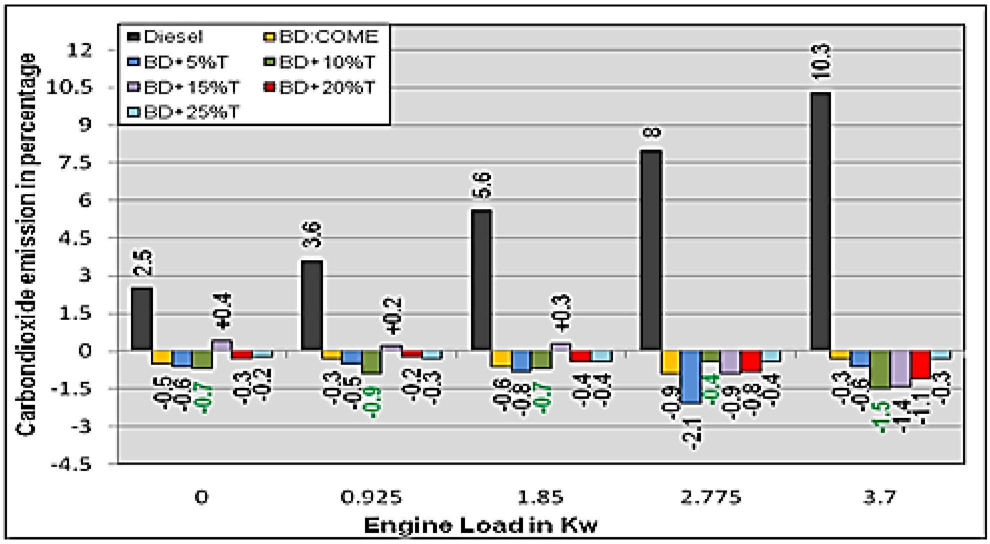

Fig.7 Variation of carbon dioxide emission verses load on engine

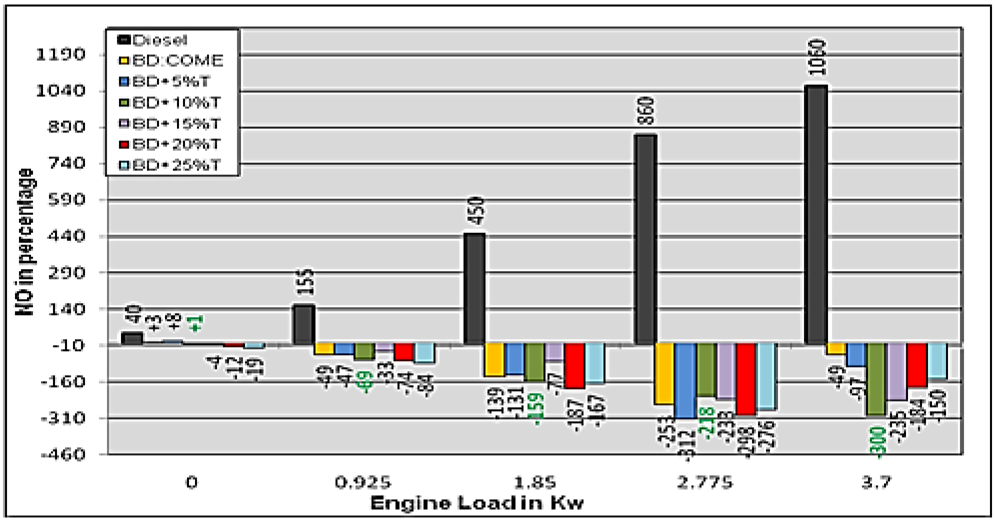

Fig.8 Variation of NO emission verses load on engine

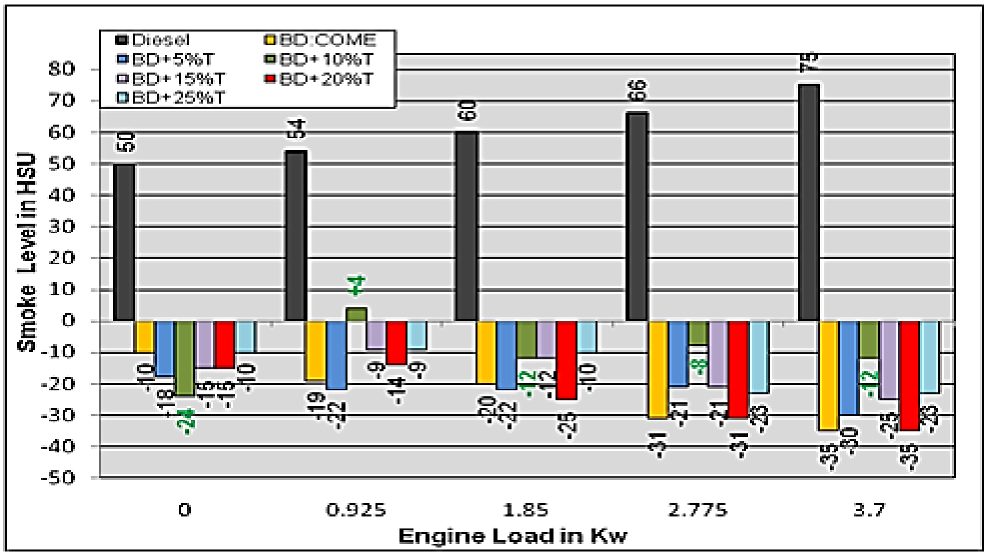

Fig.9 Variation of smoke level verses load on engine

5. Conclusions

1. Bio-diesel with Triacetin additive, which is Cetane improver, has reduced NO emissions to reasonable extent.

2. There is no tradeoff between HC and NO emissions in blending biodiesel with additive.

3. Decrease in engine smoke with additive blends application because of reduction in the carbon molecules in blends fuels.

4.The blends with triacetin produced mean effective pressures lesser than 6.5 bar eliminating them in the knocking zone. Whereas 10% triacetin blend, even though produced 7.2 bar IMEP, can be regarded as safe marginally below the IMEP ranges of diesel and biodiesel in the 80% burnt mass fraction zone and at 1500 rpm.

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