Effect of Ethanol and Biodiesel Usage in Diesel Engine- A review

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Abstract - Alternate fuels have been used to fulfill the demand of fuel for engines used at various fields and also due to the decreasing petroleum fuel resources. Moreover the very low emissions norms have led to the experimentation, analysis and optimization of operating parameters of the engines run with these alternate fuels. Optimization of operating parameters to suit these alternate fuels have led to various studies and experiments.

Index Terms - Ethanol, Biodiesel, Diesel Engine, Performance and Exhaust Emission analysis

INTRODUCTION

Engines have been used in various fields and its field of application is still increasing with the passage of time. With the increased usage of the engines, fuel required is higher and so also the demand of petroleum fuels. Alternate fuels have been used to fulfil the demand of fuel for engines and also due to the decreasing petroleum fuel resources. Moreover the very low emissions norms have led to the experimentation, analysis and optimization of operating parameters of the engines run with these alternate fuels.
There are different methods being used by various commissions to put a limit to these global problems. These methods include control of emission basically at two levels

- During combustion by changing the conditions that favour the generation of harmful emissions
- By using catalytic convertors and various other systems to convert the harmful emissions into harmless ones

The European commission for emissions have established some directives like Euro 1 to Euro 6, for reducing the emissions from light and heavy duty vehicles and these emission standards forms the base for Bharat Stage Emission Standard which is applicable to all the vehicles in India. The Euro norm (Euro I) was introduced in 1992 for the first time in the European counties. The emission norms act as the base for approval of vehicles to be used in the day to day life.
The vehicle manufacturers and academic researchers have directed their research towards the commercial diesel engines with high performance and very low emission. With this view, there are many research being conducted with alternate fuels mainly due to these reasons

- To reduce the emissions as per the norms.
- The depleting petroleum resources which at present are used as fuel for all the vehicles.
- In case of our country, to reduce the import of petroleum fuels and thus increasing the economy of the country.

These reasons have led to the investigation of renewable fuels like alcohols, hydrogen and other oxygenated fuels like biofuels.

Ethanol as alternate fuel.

Ethanol is a widely available renewable fuel which can be produced by fermentation and distillation from biomass. As a fuel for CI engines, ethanol has some advantages over diesel fuel such as reduction of soot, CO, unburned HC emission. Although having these advantages, due to limitation in technology, economic and regional considerations, ethanol still can't be used extensively. However, ethanol blended with diesel can be used as fuel in CI engines.

Ethanol has higher miscibility in diesel than methanol. As given by Ozer Can et al[7] in their paper, using ethanol-diesel blend has disadvantages like lower miscibility at lower temperature, Phase separation and lower heating value, cetane number and viscosity[7][6]. In addition, they reported that ethanol-containing diesel fuel exhausted greater formaldehyde, formic acid, and acetaldehyde emissions than did normal diesel. Additives (propanol and various biofuels) are used to enhance phase stability, improve cetane number, and reduce ignition delay and cycle irregularities [6] [3]. Different additives perform their own unique action on its addition to the blend of fuel. In the last few years many studies on the IC engine have been carried out aiming to reduce exhaust emissions by changing operating parameters such as valve timing, injection timing and pressure, compression ratio and also atomisation rate.

CI Engines and Fuel Properties

Properties	Diesel	Ethanol
Density (gm/cc)	0.830	0.810
Boiling point, ºC	180-340	78.37
Calorific Value, kJ/kg	42,000	29860

Flash point, ºC	55	171.1
Autoignition Temp. ºC	210	368
Cetane number	51	8
Octane number	Lower than Ethanol	109
Vaporization temp. ºC	Higher than Ethanol	77.86
Stoichiometric air-fuel ratio	14.7	9

Effect of various properties of fuel on engine [2]

- **Oxygen and carbon content**

• The carbon when excess gets deposited in the form of soot and has a tendency to extinguish the flame front and stifle combustion.
• Oxygen increases the probability of complete combustion and so decreases unburned or partially burned molecules emission like HC and CO.
• Soot(C-C) formation in the engine greatly decreases with oxygen presence as carbon has higher affinity to oxygen.
• Oxygen presence reduces lubricity to a greater extent. Thus results in wear of fuel injector.

Ethanol's lower carbon content and high oxygen with all these effects reduces CO, HC and soot formation. But this happens only during high load conditions as the oxygen bond is too strong and needs high pressure and temperature to break it.

- **Sulphur content**

• Fuel sulphur is chemically changed during combustion to form sulphuric acids, which attacks metal surfaces and causes corrosive wear.
• Sulphur content can affect emission control systems performance, which in turn can increase particulate emissions.

Ethanol has negligible sulphur; it reduces corrosion of engine parts due to acid formation.

- **Stability and phase separation**

• Low temperatures and high water contamination are more likely to advance the start of fuel instability and phase separation.
• Under most conditions, ethanol readily blends with gasoline at all ratios. Unlike gasoline, diesel fuel is not easily blended with ethanol under all condition. Particularly troublesome are conditions of low temperature and water contamination. Both can result in fuel instability due to phase separation.

- **Carbon residue**

• The tendency of a fuel to form carbon deposits in an engine can be estimated by various tests to determine the carbon residue after 90% of the fuel has been evaporated.
• Presence of carbon deposits may influence combustion and hence resulting in inefficient combustion.
• In Ethanol, it is negligible due to presence of excessive oxygen.

Effective Use of Ethanol in Engines

Eloisa Torres-Jimenezet al [3], discusses the physical–chemical properties of ethanol–diesel fuel blends. The attention is focused on the properties which influence the injection and engine characteristics significantly. Main properties have been investigated experimentally. The tested fuels were neat mineral diesel fuel (D100), 5% (v/v) ethanol/diesel fuel blend (E05D95), 10% (v/v) ethanol–diesel fuel blend (E10D90) and 15% (v/v) ethanol–diesel fuel blend (E15D85). It was observed that,

• Additives are necessary to keep stability of tested ethanol–diesel fuel blends under low temperature conditions.
• Ethanol addition improved lubricity of diesel fuel, contrary to what occurs in case of pure components and does not provide higher corrosion compared to that of neat diesel fuel.
• Carbon and hydrogen components decrease by ethanol addition, leading to a slightly reduction in lower specific energy content.
• Meanwhile the increase in oxygen content (in blends with ethanol) is expected to have a beneficial effect on the emissions profile compared with the use of direct diesel fuel and to enhance combustion efficiency of the fuel.

MetinGumuset al [4], studied the effects of fuel injection pressure on the exhaust emissions and brake specific fuel consumption (BSFC) of a direct injection (DI) diesel engine have been discussed. The engine was fuelled with biodiesel–diesel blends when running the engine at four different fuel injection pressures (18, 20, 22, and 24 MPa) and four different engine loads in terms of mean effective pressure (12.5, 25, 37.5, and 50 kPa). The study provides that,

• Bio-diesel has oxygen content in it, that is useful to reduce CO, UHC and Smoke opacity
• The increase in engine load caused to some increase in exhaust gas temperature, smoke opacity, the emissions of CO2, CO and NOx, and to decrease in BSFC, the emissions of UHC and O2.
• Increasing the amount of biodiesel in the fuel mixture produced higher peak temperature in the cylinder. But this effect increased NOx emissions.
• Increased injection pressure caused to decrease in smoke opacity, UHC, and CO, and it caused to increase in the emissions of CO2, O2 and NOx.

CenkSayinet al [5]investigates the influence of compression ratio (CR) and injection parameters such injection timing (IT) and injection pressure (IP) on the performance and emissions of a DI diesel engine using biodiesel (%5, 20%, 50%, and 100%) blended-diesel fuel. Tests were carried out using three different CRs (17, 18, and 19/1), ITs (15, 20, and 25 CA BTDC) and IPs (18, 20 and 22 MPa) at 20 N m engine load and 2200 rpm. The following were observed,

- BSFC, BTE and BSEC are considerably improved with the increase in CR. This is due to increase in density of air , which further leads to higher oxygen content for more complete combustion.
- For all CRs, the emissions of HC, OP and CO with biodiesel blends are lower than that of diesel fuel.
- With a very high increase in CR, the temperature reached is also high and so less OP, CO and HC emissions are exhausted in engine. But, this effect increased NOx emissions.
- The increased IP gave the better results for BSFC, BSEC and BTE. Finer breakup fuel droplets obtained with increased IP provide more surface area and better mixing with air and this effect improve combustion.

Su Han Parket al [6] studied the atomization characteristics of ethanol diesel biodiesel blend. This study was conducted to investigate the injection and atomization characteristics of biodiesel–ethanol blended fuel. The injection performance of biodiesel–ethanol blended fuel was analysed from the injection rate characteristics using the injection rate measuring system, and the effective injection velocity and effective spray diameter using the nozzle flow model. The observations made were,

- At the same injection conditions, the peak injection rate and injection delay of ethanol blended biodiesel fuel are lower and advanced compared to D100 and BD100 fuel.
- The droplet size of the ethanol blended biodiesel (BDE20) was smaller than that of undiluted biodiesel (BD100).
- Ethanol addition improved the atomization performance of biodiesel fuel, because the ethanol blended fuel has a low kinematic viscosity and surface tension, then that has more active interaction with the ambient gas.

IsmetCelıkten[7]studied the effects of injection pressure on engine performance and exhaust emissions have been investigated. Experiments have been performed on a turbocharger diesel engine with 4-cylinder, 4-stroke, indirect injection. Emissions and engine performance values such as torque, power, break main effective pressure, specific fuel consumption, and fuel flow have been measured both full and part loads by changing injection pressure from 100 to 250 bar and for different throttle positions. The experiment showed that,

- Injection spray pressures in diesel engines playan important role for engine performance and emissions obtaining treatment of combustion.
- Engine performance values are maximum at 150 bar.
- Higher injection pressure for must be preferred for decreasing O2, SO2 and CO2.
- Low injection pressure must be preferred for decreasing emissions like NOx and smoke level.
- Control of diesel engine injection pressures is very important and it can be effective if variable injection pressure instead of constant injection pressure using Electronic Control System.

1. Concluding Remarks

The Literature review showed that,

- Additives (propanol and various biofuels) are used to enhance phase stability, improve cetane number, and reduce ignition delay and cycle irregularities. Different additives perform their own unique action on its addition to the blend of fuel. Additives that have been used are 1-octylamino-3-octyloxy-2-propanol, 2-nitrato-3-octyloxy propyl.
- Ethanol increases the volumetric efficiency as the intake air is cooled due to high latent heat of vaporization.

[1] Effect of ethanol addition on emissions Reduced SO2 and smoke emissions as ethanol has less carbon and has oxygen molecule in it

[2] Reduced NOx as ethanol reduces the temperature of the combustion chamber due to low heating value(low flame temperature)

[3] Reduced soot formation as there is oxygen molecule in ethanol which decreases C-C bond formation and forms CO.

[4] Reduced heating value suppresses oxidation of CO to CO2 and hence increased CO emission at low load condition. But in other load conditions CO oxidation to CO2 increases and hence CO emission decreases which is a favourable impact.

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