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# Effect of piston coating on the performance and emission characteristics of the diesel engine with Palmstearin blends (palm stearin+ camphor oil)

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***Abstract*** *-- In recent years, the usage of vehicles has been increased and this leads to the demand for fossil fuels. It has become an urgent need to carry out the research work on alternate source of energy to reduce the demand of fossil fuels and also to reduce the emission. Biofuel is one of the alternative sources of energy. The aim of the paper is to blend the camphor oil with diesel fuel at various proportions by volume. The camphor oil is directly blended with diesel fuel without any trans-esterification process, because of its low viscous property. Approximately one third of the total fuel input energy was converted into useful work and two-third has been lost through exhaust gas and cooling system. In a standard engine, a large percentage of energy is wasted through the cooling and exhaust system.*

*So, to minimize these losses the combustion chamber Piston crown is coated with ceramic materials without changing the original dimensions. Tests were conducted and comparison is done between coated and uncoated engines. Many authors/researchers have made one step ahead by using bio-diesel or by altering the injection timing. Their results have showed improved engine performance and emission characteristics. Zirconia and Alumina is considered to be the most suitable material for ceramic coating. Plasma spray coating is widely accepted technique.*

***Index Terms— Diesel, Camphor Oil, Viscosity, Ceramic coating, plasma spray coating method, engine performance and emission characteristics.***

## 1. INTRODUCTION

Alternative fuels, known as non-conventional or advanced fuels, are any materials or substances that can be used as fuels, other than conventional fuels like; fossil fuels (petroleum (oil), coal and natural gas), as well as nuclear materials such as uranium and thorium, as well as artificial radioisotope fuels that are made in nuclear reactors.

A comprehensive study prepared for the Transportation Table entitled Alternative and Future Fuels and Energy Sources for Road Vehicles reviewed production processes and resource supplyissues affecting fuel production, estimated fuel production costs, and quantified fuel cycleemissions of potential alternative fuels.

### 1.2 Camphor oil

Camphor essential oil is extracted from the CinnamomumCamphora (also known as Lauruscamphora) of the Lauraceae family and is also known as true camphor, hon-sho, gum camphor, as well as Japanese and Formosa camphor. Although this oil has got some toxic effects, it can be used with great effect in vapor therapy to clear the lungs, dispel apathy and calm nervous depression. It has a beneficial effect on any psychosomatic ailments, while having some distinct benefits for the skin when used with great care.

### Oil properties

After distillation and rectification under vacuum it is filter pressed and 3 fractions of oil are produced known as white, yellow and brown camphor. Only the white camphor oil is used and has a clear and fresh smell. The brown and yellow camphor is toxic and carcinogenic since it contains safrole and is not used in aromatherapy.

### 1.3 Properties of camphor oil Comparison with diesel

Table 1 :Properties of camphor oil Comparison with diesel

| Properties | Units | Diesel | Camphor Oil |
|---|---|---|---|
| Density at 15$^0$C | kg/m$^3$ | 840 | 894.2 |
| Kinematic viscosity at 40$^0$C | CSt | 3.4 | 1.9 |
| at 40$^0$C Flash point | $^0$C | 50 | 50 |
| Fire point | $^0$C | 72 | 68 |
| Cetane number | - | 52 | 5 |
| Calorific value | kJ/kg | 42700 | 38200 |

**Palm stearin oil**

Palm oil (also known as dendê oil, from Portuguese) is an edible vegetable oil derived from the mesocarp (reddish pulp) of the fruit of the oil palms, primarily the African oil palm Elaeis guineensis,[1] and to a lesser extent from the American oil palm Elaeis oleifera and the maripa palm Attalea maripa.

Palm oil is naturally reddish in color because of a high beta-carotene content. It is not to be confused with palm kernel oil derived from thekernel of the same fruit,[2] or coconut oil derived from the kernel of the coconut palm (Cocos nucifera). The differences are in color (raw palm kernel oil lacks carotenoids and is not red), and in saturated fat content: palm mesocarp oil is 41% saturated, while palm kernel oil and coconut oil are 81% and 86% saturated fats, respectively.

## 1.4 Emissions

Diesel engines are the primary power source of vehicles used in heavy duty applications. The heavy duty engine includes buses, large trucks, and off highway construction and mining equipment's. Further more,diesel engines are winning an increasing share of the light duty vehicle market world wide. The popularity of the diesel engine revolves around its fuel efficiency, reliability, and durability. High compression ratios along with relatively high oxygen concentrations in the diesel combustion chambers are responsible for the good fuel efficiency and low CO and hydrocarbon emissions when contraste to acomparable gasoline engine. The CO present in residual gas in diesel engine is also less compared with petrol engine. However, the sesame factors result in high $NO_X$ emissions.

### 1. Hydrocarbon

Hydrocarbon emission is the consequence of incomplete combustion of the hydrocarbon fuel. The level of unburned hydrocarbon in the exhaust gases is generally specified in terms of the total hydrocarbon concentration expressed in parts per million carbon atom. The fuel which escapes from normal combustion process leads to the emission of unburnt hydrocarbon. In diesel engines,the fuel canescape from combustion process due to two reasons; the fuel- air mixture is toole anortoorichto igniteorto support a propagating flame at the conditions prevailing inside the combustion chamber of diesel engine.This fuel the can be consumed only by slower thermal oxidation reaction laterin the expansion process.

### 2. Carbonmonoxide

Carbon monoxide is the product of incomplete combustion when the engine is operated with fuel rich equivalence ratio. CO is not only considered as undesirable emission, but also represents loss of chemical energy. The exhaust of typical spark ignition engine contains 0.2 to 5% CO where as the diesel engine exhaust contains very low percentage of CO as the engine is normally operated at lean conditions.

### 1.5 THERMAL BARRIER COATINGS

Thermal barrier coatings are duplex systems, consisting of a ceramic top coat and a metallic intermediate bond coat. The top coat consists of ceramic material whose function is to reduce the temperature of the underlying, less heat resistant metal part. The bond coatis designed to protect the metallic substrate from oxidation and corrosion and promote the ceramic top coat adherence. A thermal barrier application is shown in figure1

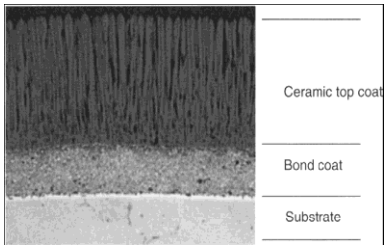


Fig1.Thermal barrier coating consisting of metallic bond coat on the substrate and ceramic top coat on the bond coat

**ADVANTAGES OF THERMAL BARRIER COATINGS FOR DIESEL ENGINES**

Some advantages of thermal barrier coatings on diesel engines are below.

| Property | Requirement | Rationale |
|---|---|---|
| Melting point | High | Operating environmental high |
| Thermal conductivity | Low | Temperature reduction inversely proportional to thermal conductivity |
| Coefficient of thermal expansion | High | Expansion should be close to that of super alloy substrate and bond coats on which coatings are deposited |
| Phase | Stable | Phase change in thermodynamic cyclic environment is structurally detrimental |
| Oxidation resistance | High | Operating environment highly oxidizing |
| Corrosion resistance | Moderate to high | Operating environment may be corrosive |
| Strain tolerance | High | Operating environment imposes large stain ranges |

- Low cetane fuels can be burnt.
- Improvements occurs at emissions except NOx
- Waste exhaust gases are used to produce useful shaft work,
- Increased effective efficiency,
- Increased thermal efficiency,
- Using lower-quality fuels with in a wider stillationrange,
- The faster vaporization and the better mixing of the fuel,
- Reduced specific fuel consumption,
- Multi-Fuel capability,
- Improved reliability,

**Zirconates**

The main advantages of zirconatesare their lows intering activity, low thermal conductivity, high thermal expansion coefficient and good thermal cycling resistance. The main problem is the high thermal expansion coefficient which results in residual stress in the coating, and this can cause coating delamination.

## 2. EXPERIMENTAL SETUP

This experimental setup consists of four stroke diesel engine connected with electrical loading. By using this experimental setup estimating the performance and emission analysis at different loading conditions and different diesel blends and with piston coating and without piston coating.

The engine specifications are
Bore : 80 mm
Stroke : 110 mm
RPM : 1500
BHP : 5
CR : 16:1
Generator efficiency: 80 %

**TEST RIG:**

FIG 2: 4 Stroke single cylinder diesel engine set up with generator loading

**Experimental procedure**

Initially the engine is running with diesel fuel for the duration of 10 to 15 minutes before using camphor oil blends in order to attain stable working environment. After that diesel fuel is completely drained out from the fuel tank and then the sample of (500 ml) camphor oil-diesel blends are poured into the fuel tank. It is important to note that whether the engine has attained its optimum (warm) temperature conditions. At constant speed of 1500 rpm, engine is loaded with 0%, 5%,25%, 50%, 75%, 100% load by using an eddy current dynamometer. The B15 & B20 proportions of camphor oil blends are tested at all load conditions running at constant speed, where the

experimental procedure is same for every proportion to be tested.

## 3.Comparison graphs For Fuel injection For Fuel injection pressure 180 bar

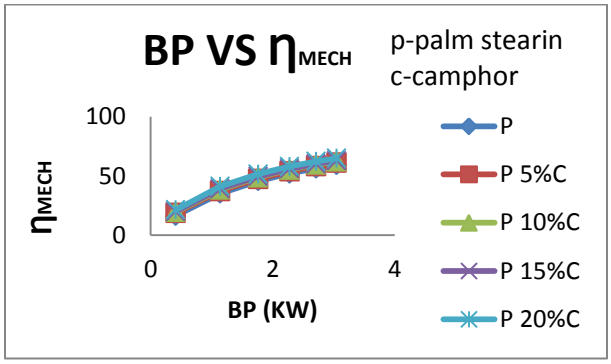


Fig 3.1: Performance of Palmstearin blends at 180 bar pressure BP VS $\eta_{mech}$

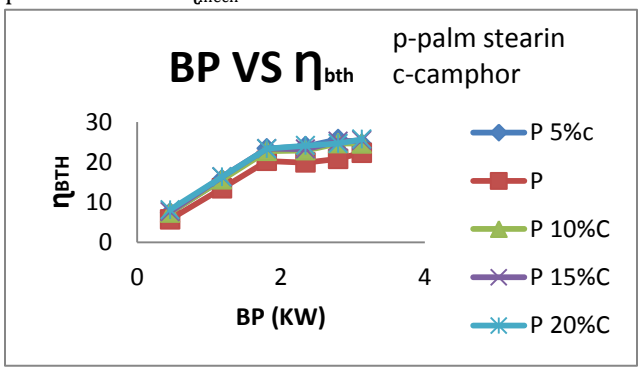


Fig 3.2: Performance of Palm stearin blends at 180 bar pressure BP VS $\eta_{bth}$

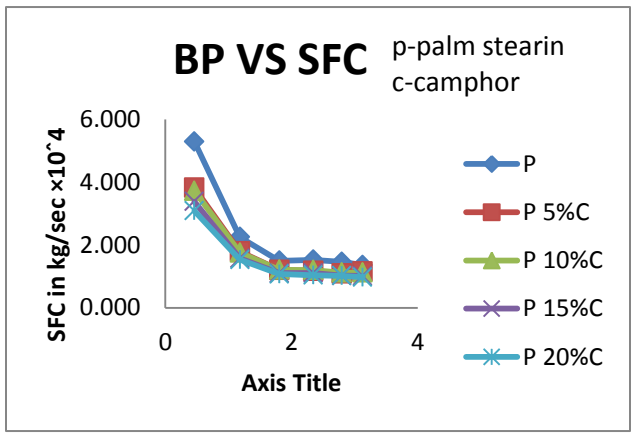


Fig 3.3: Performance of Palm stearin blends at 180 bar pressure BP VS SFC

**For fuel injection pressure 210 bar**

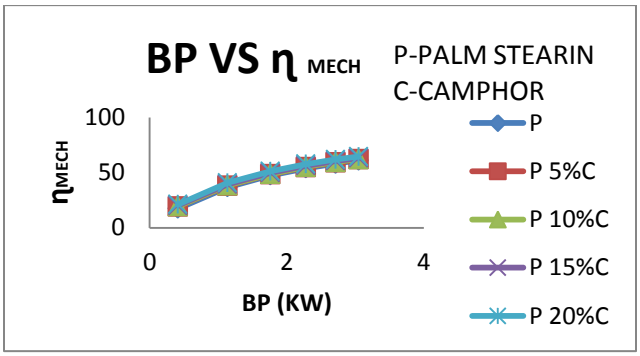


Fig 3.4: Performance of Plam stearin blends at 210 bar pressure BP VS $\eta_{mech}$

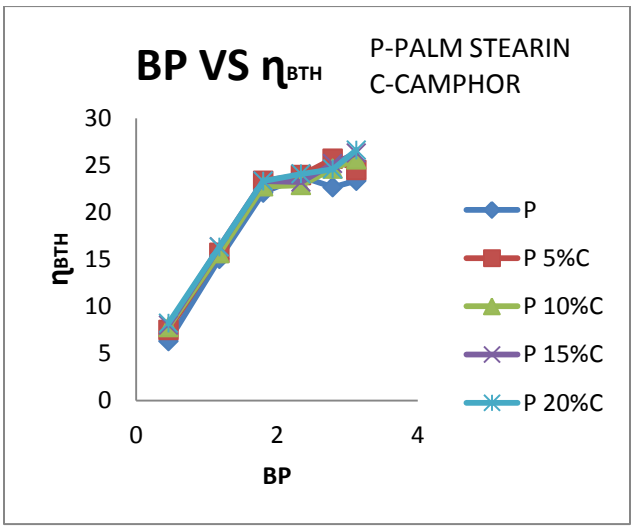


Fig 3.5: Performance of Palmstearin blends at 210 bar pressure BP VS $\eta_{bth}$

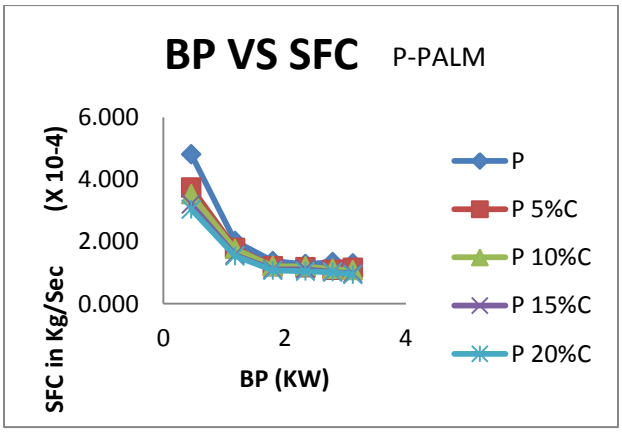

Fig 3.6: Performance of Palmstearin blends at 180 bar pressure BP VS SFC

With this above results Palm stearin and camphor 20% blend is giving better performance characteristics and by comparing fuel injection pressures 210 and 180 bar in this 210 bar is giving better results.

**For Fuel Injection Pressure 210 bar**

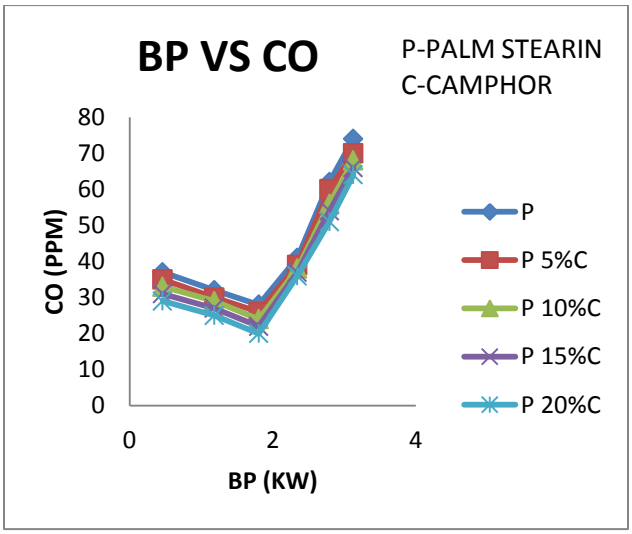


Fig 3.7: Emission characteristics of palm stearin blends BP VS CO at 210 bar pressure

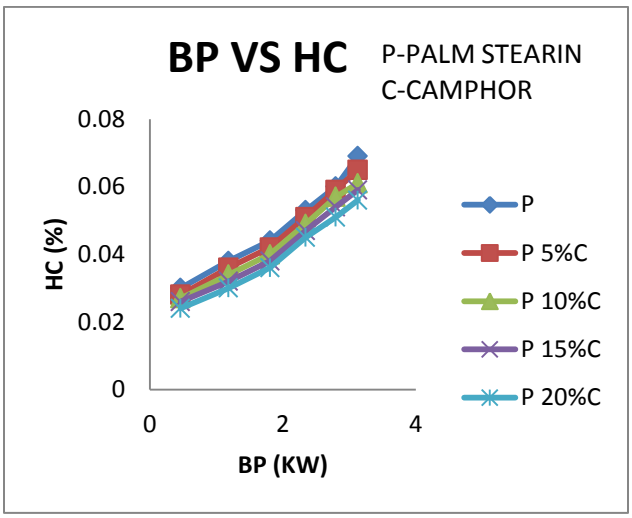


Fig 3.8: Emission characteristics of palm stearin blends BP VS HC at 210 bar pressure

The emissions characteristics of the diesel engine with 210 bar is giving less emissions when compared with 180 bar.

The emission characteristics of the diesel engine with Palm stearin blends is giving more emissions compared with pure diesel when operating at 210 bar

### 3.2 Performance of Palm stearin blends (Palm stearin +Camphor oil) with zirconium oxide coating on piston crown

The experiments are carried out to recognize which will gives the better performance characteristics of the diesel engine.

**For Fuel injection pressure 210 bar**

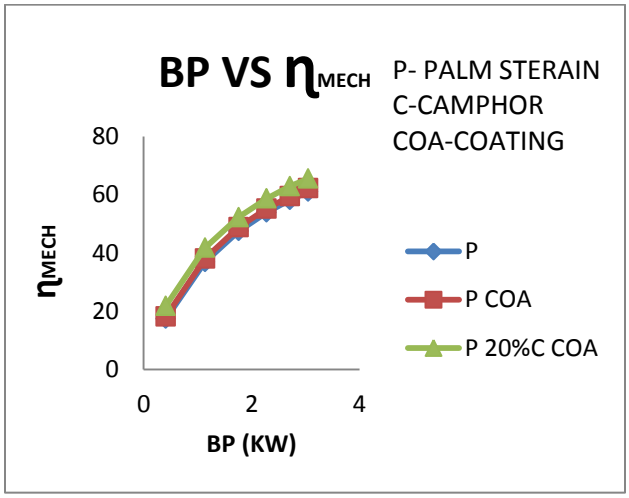


Fig 3.9: Performance of Palmstearin blends at 210 bar pressure BP VS $\eta_{mech}$

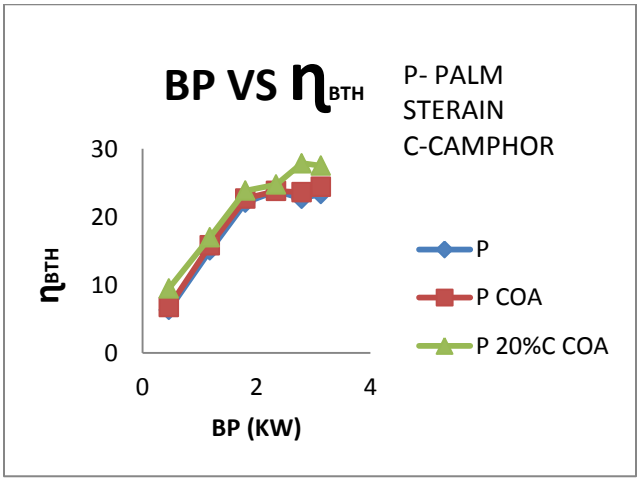


Fig 3.10: Performance of Palmstearin blends at 210 bar pressure BP VS $\eta_{bth}$

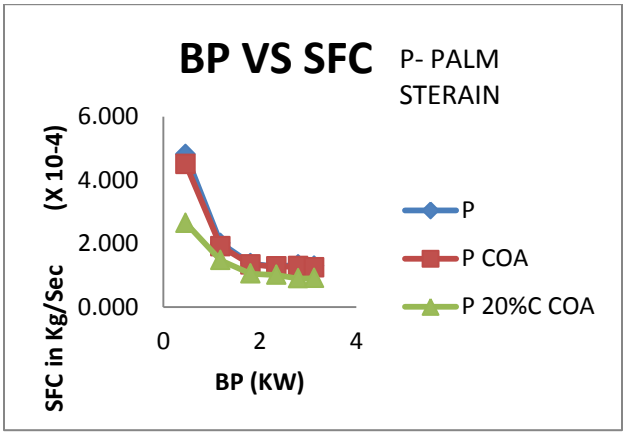


Fig 3.11: Performance of Palmstearin blends at 210 bar pressure BP VS SFC

After all the evaluation of the results the performance and emissions characteristics of the diesel engine with 20% camphor oil and 80% Palm stearin oil with zirconium oxide coating will gives better results.

### 3.3 Emissions for diesel engine with palm stearin blends (Palm stearin+Camphor) with zirconium oxide coating

**For Fuel injection pressure 210 bar**

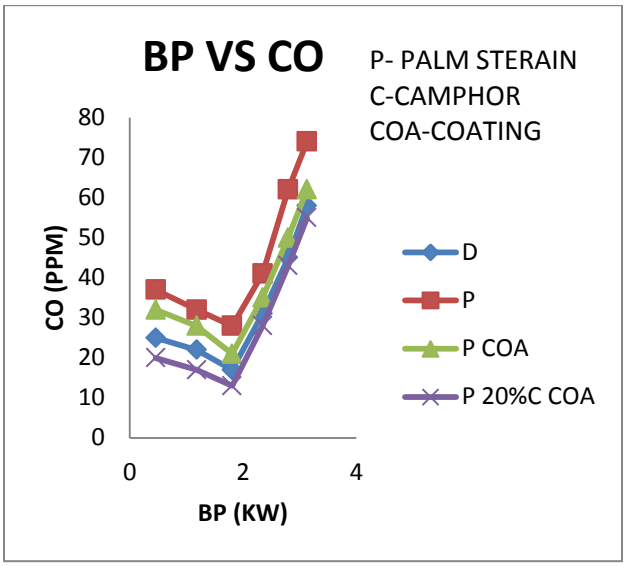


Fig 5.14: Emission characteristics of palm stearin blends BP VS CO at 210 bar pressure

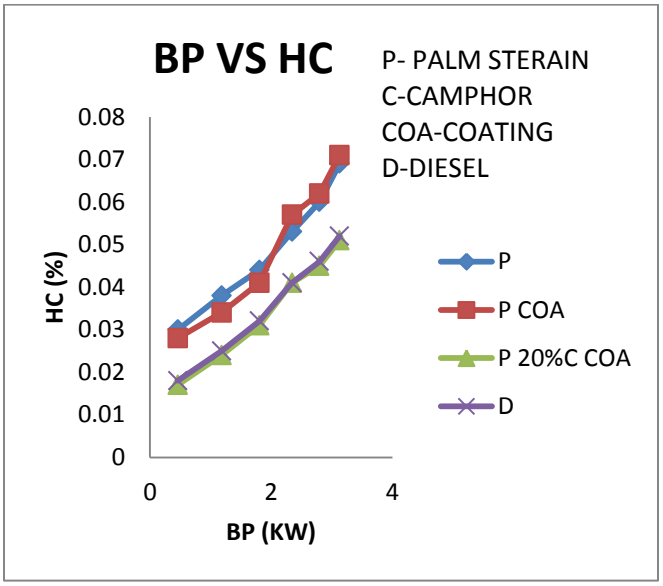


Fig 3.13: Emission characteristics of palm stearin blends BP VS HC at 210 bar pressure

### 4.CONCLUSION

The performance of the diesel engine with palmstearin blend (20% of camphor) with coating is, brake thermal efficiency increased by 3.54%, mechanical efficiency by 2%, specific fuel consumption by 2% and

emissions decreased with coating that is CO emissions reduced by 5% and HC emissions reduced by 2% when we compare with pure diesel operation without coating and cost of the fuel is increased by 5 Rs\-.

The performance and emission characteristics of the engine with palm stearin blends 20% is giving better results but emission characteristics are high at peak loads. When the engine is operated with coating the emission characteristics of the engine is less compared with diesel. This is achieved because of usage of the camphor oil which is having low viscosity and palm stearin properties are nearly similar to the diesel oil but emissions are reduced because of the zirconium oxide coating. The zirconium oxide coating will gives thermal resistance to give more usage of the fuel that will reduce the emissions and also increase the performance characteristics of the diesel engine.

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