Effect of CETANE Improver Additives on Emissions

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ABSTRACT: *Exhaust gases of an engine can have upto 2000 ppm of oxides of nitrogen.Most of this will be nitrogen oxide(NO), with a small amount of nitrogen dioxide(NO_2).NO_x is very undesirable.Regulations to reduce NO_x emissions continue to become more and more stringent year by year. Released NO_x reacts in the atmosphere to form ozone and is one of the major causes of photochemical smog. NO_x is created mostly from nitrogen in the air. Nitrogen can also be found in fuel blends. At high temperature and pressure higher levels of NO_x is created and at low temperature lower level of NO_x is produced. In addition to temperature,the formation of NO_x depends on pressure and air-fuel ratio. Engine emission from diesel fuel ,paying special attention to the most concerning emissions. Oxides of nitrogen is not only in mass and composition but also in size distributions. Many of the design changes for reduction in NOx emissions result in higher brake specific fuel consumption. Test is carried out in a single cylinder direct injection diesel engine. Cetane number describes the auto ignition quality of the diesel fuel. Cetane improver additive of neopentane is used with the varying proportions of 1ml,3ml,5ml to the diesel fuel respectively. Addition of cetane improver additive to the diesel fuel is cost effective way to control NOx emission. Diesel fuel with the 3ml additive of neopentane shows the significant reduction in NOx and smoke .The sensitivity of NOx to change in cetane number is higher at low load than at high load.It is found that NOx emissions were reduced at low load than at high load.*

KEYWORDS: *NOx, HC, CO, Cetane additive.*

I. INTRODUCTION

Emissions from automobiles were identified for the first time as a major contribution to urban air pollution during 1950's.Photochemical reactions between unburned hydrocarbons and nitrogen oxides emitted mostly by vehicles were found responsible for production of a host of secondary pollutants including ozone and other oxidants in atmosphere. The 'brown haze' appearing above the ground level in the Los-Angeles area as a result of the photochemical reactions between the vehicular air pollution ,the amount of emissions depending largely on their design ,operating conditions and the characteristics of the fuel.

The increased industrialization and motorization of the world in recent years has resulted in great demand for petroleum products. Petroleum is the largest single source of energy which has been consuming by the world's population, exceeding the other energy resources such as natural gas, coal, nuclear and renewable. 90% of energy consumption of the world is from petroleum fuels. Petroleum based natural gas, coal, nuclear and renewable. Petroleum based fuels are obtained from limited reserves and estimated to last only for new decades.

According to international Energy Outlook 2007 published by the Energy Information Administration, the world consumption for petroleum and other liquid fuel will grow from 83 million barrels/day in 2004 to 97 million barrels/day in 2015 and just over 118 million barrels/day in 2025 under these growth assumptions, approximately half of the world's total resources would be exhausted by 2025. Therefore the future energy availability is a serious problem for us.

Major global concern is environmental concern or climate change such as global warming. Global warming is related with the green house gases which are mostly emitted from the combustion of petroleum fuels. The Intergovernmental Panel on Climate Change (IPCC) concludes in the Climate change 2007 that, because of global warming effect the global surface temperatures are likely to increase 1.1C to 6.4C between 1990 and 2100.

II. CETANE NUMBER & ADDITIVE

Cetane number or CN is a measurement of the combustion quality of diesel fuel during compression ignition. It is a significant expression of diesel fuel quality among a number of other measurements that determine overall diesel fuel quality.

Cetane number or CN is actually a measure of a fuel's ignition delay; the time period between the start of injection and the first identifiable pressure increase during combustion of the fuel. In a particular diesel engine, higher cetane fuels will have shorter ignition delay periods than lower cetane fuels. Cetane numbers are only used for the relatively light distillate diesel oils.

III. TYPICAL VALUES

Generally, diesel engines run well with a CN from 40 to 55. Fuels with higher cetane number which have shorter ignition delays provide more time for the fuel combustion process to be completed. Hence, higher speed diesels operate more effectively with higher cetane number fuels. There is no performance or emission advantage when the CN is raised past approximately 55; after this point, the fuel's performance hits a plateau. Dimethyl ether may prove advantageous as a future diesel fuel as it has a highcetane rating(55) and can be produced as a biofuel. Alkyl nitrates (2-ethyl hexyl nitrate) and di –tert-butyl peroxide are used as additives to raise the cetane number.

CETANE ADDITIVE:

Generally, cetane additive is used in the diesel engine for controlling NO_x emissions .There are certain cetane additives used widely, as Ethyl hexyl nitrate, alkyl nitrate,peroxide compounds, methyl oleate. In this paper Di-MethylPropane (DMP) or Neopentane is used as the cetane additive. DMP is a highly volatile liquid on a cold day in an ice bath, or when compressed to high pressure. DMP is an extremely flammable gas at room temperature. When DMP is added to the canola methyl ester it will result in better auto-ignition of the fuel and low NO_x emission. DMP is added as 1ml,3ml,5ml to the diesel fuel.

PROPERTIES OF DMP:

Boiling point :9.5ºC
Molar mass :72.15 g mol¯1
Melting point : -17ºC,256 K,1ºF
Exact mass : 72.0939900384 g mol¯1
Chemical formula:C_5H_{12}

DIESEL ENGINE POLLUTANTS

The pollutants from diesel fuel vehicles are Particulate Matter (PM), smoke, NO_x, Sulphur di-oxide, CO and HC. Most pollutants are emitted from the exhaust. Because diesel engines operate at high air-fuel ratios, they tend to have low HC and CO emissions. They have considerably higher PM emissions than gasoline-fueled vehicles; however, for heavy-duty vehicles CO, HC and NO_x emissions in the exhaust also vary with driving modes, engine speed and load.

POLLUTANT FROM DIESEL ENGINE

Smoke, Oxides of Nitrogen,Particulate matter, Oxides of Sulphur and Hydro carbon.

FOLLOWING FACTORS CAUSE THE POLLUTANTS

- Incomplete combustion,
- Injection of fuel
- Air-fuel ratio
- Time of injection
- High excess air
- Availability of oxygen
- Fuel atomization

IV. MECHANISM OF NOx FORMATION

One of the primary diesel engine pollutants, NOx is formed by reaction between oxygen and nitrogen in the combustion chamber. NOx formation dramatically increases with increasing combustion temperature, combustion efficiency, and combustion pressure.

NOx emissions can be reduced by reducing power, lowering the intake air temperature, retarding the injector timing, reducing the coolant temperature, and/or reducing the combustion temperature. These often reduce fuel economy.

$$NO + HO_2 \rightarrow NO_2 + OH$$
$$NO_2 + O \rightarrow NO + O_2$$

During the "premixed" or uncontrolled diesel combustion phase immediately following the ignition delay, fuel-air mixture with spread in composition about stoichiometric burns due to spontaneous ignition and flame propagation.

CARBON MONOXIDE

Diesels, however, always operate well on the lean side of stoichiometric air fuel ratio CO emissions from diesels are low enough to be unimportant, therefore, and will not be discussed further.

HYDROCARBON FORMATION MECHANISM

Diesel fuel contains hydrocarbon compounds with higher boiling points, and hence higher molecular weights, than gasoline. Also, substantial pyrolysis of fuel compounds occurs within the fuel sprays during the diesel combustion process.

Hydrocarbon emission levels from diesels vary widely with operating conditions, and different HC formation mechanisms are likely to be most important at different operating modes. Engine idling and light-load operation produce significantly higher hydrocarbon emissions than full-load operation.

Wall temperatures affect HC emissions, suggesting that wall quenching is important, and under especially adverse conditions very high cyclic variability in the combustion process can cause an increase in HC due to partial burning and misfiring cycles.

PARTICULATE FORMATION MECHANISM

Diesel particulates consist principally of combustion generated carbonaceous material (soot) on which some organic compounds has become absorbed. Most particulate material results from incomplete combustion of fuel hydrocarbon; the lubricating oil contributes some. The composition of particulate matter depends on the conditions in the engine exhaust and particulate collection system. At temperatures above 500°C, the individual particles are principally clusters of many small spheres or spherules of carbon (with a small amount of hydrogen) with individual spherule diameters of about 15 to 30 nm. As temperatures decrease below 500°C, the particles become coated with adsorbed and condensed high molecular weight organic compounds which include: unburned hydrocarbons, oxygenated hydrocarbons. The condensed material also includes inorganic species such as sulfur dioxide, nitrogen dioxide and sulfuric acid.

V. EXPERIMENTAL PROCEDURE

The engine was allowed to run with sole fuel at various loads for nearly 10 minutes to attain the steady state and constant speed conditions. Then the following observations were made.

1. The water flow was maintained constant throughout the experiment.
2. The load, speed and temperature indicators were switched on.
3. The engine was started by cranking after ensuring that there is no load.
4. The engine was allowed to run at the rated speed of 1500 rev/min for a period of 20 minutes to reach the steady state.
5. The fuel consumption was measured by a stop watch.
6. Smoke readings were measured using the Hartridge Smoke meter at the exhaust outlet.
7. The amount of NO_x was measured using exhaust gas analyzer.
8. The exhaust temperature was measured by using a sensor.

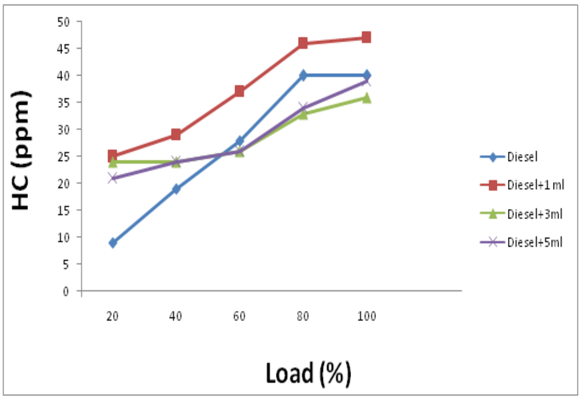
9. Then the load was applied by adjusting the knob, which was connected to the Eddy Current Dynamometer.
10. Load is applied gradually by 20,40,60,80,100 respectively.
11. Each readings of the load is noted .
12. First, diesel in used in the engine and the reading are noted.
13. The engine is run by diesel with adding 1ml of DMP.
14. The engine is run by diesel with adding 3ml of DMP.
15. The engine is run by diesel with adding 5ml of DMP.
16. Experiment is conducted using sole fuel and sole fuel with additive of Neopentane.

17.From the readings of Added DMP, without DMP graph is plotted based on the tabulated reading.

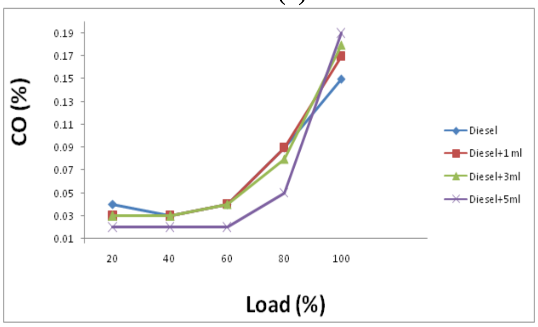
VI. RESULTS AND DISCUSSION

Fig (a) shows that the variation in hydrocarbon emission with time for different loads of sole diesel fuel and diesel fuel with additive of Neopentane . From low load to high load application HC emission is increased .At high load condition the friction power found to be higher than no load condition. At high load condition more amount of fuel is admitted.HC emission is remarkable in the idling and low load because of high heat of vaporization of the fuel.

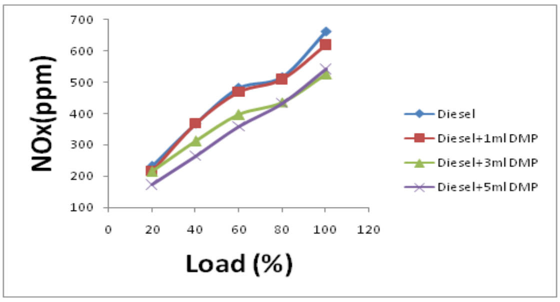
Fig(b) shows that the variation in Carbon monoxide emission with time for different loads of diesel fuel and diesel fuel with additive of Neopentane.CO concentration is lower at the idling and low load and it is slightly increased at high load because an increased premixed combustion due to o longer ignition delay.



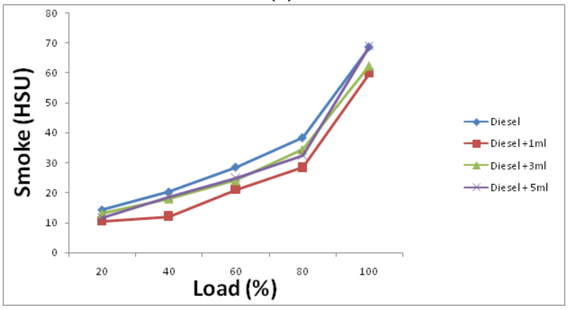
(a)



(b)



(c)



(d)

Fig(c) shows that the variation in Oxides of nitrogen emission with time for different loads of diesel fuel and diesel fuel with additive of Neopentane. NOx emission increases with the increase of load and slightly increases with the addition of cetane improver.Due to the high engine operating temperature at high load NOx is slightly increased. In addition to temperature formation of NOx depends on pressure and air-fuel ratio.

Fig(d) shows that the variation in Smoke emission with time for different loads of diesel fuel and diesel fuel with additive of Neopentane. Carbon spheres are generated in the combustion chamber in the fuel rich zones where there is not enough oxygen to convert all carbon to CO_2.Because of the high compression ratios of CI engines, a large expansion occurs during the power stroke. A single soot particle may contain upto 5000 carbon spheres.

VII. CONCLUSION

Emission characteristics of the single cylinder diesel engine with DMP or Neopentane as an Cetane improver additive were investigated with different load conditions. The result of the study are summarized as follows:

1. From the emission analysis it is observed that there is a 21% reduction in NOx emission with the 3ml of DMP at full load, without increasing the smoke level.
2. HC, CO emission is reduced by 17%, 20% respectively.
3. From the above analysis, it is found that 3ml of DMP with diesel fuel produces significant reduction in NOx, HC, CO emission than the sole diesel fuel,1 ml of DMP with diesel fuel,5 ml of DMP with diesel fuel.
4.0.003% of DMP is selected as the suitable proportion of a cetane improver for the significant reduction of emissions in the single cylinder diesel engine.

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