Int. J. Chem. Sci.: 14(4), 2016, 2835-2844
ISSN 0972-768X
www.sadgurupublications.com

INVESTIGATION ON EFFECT OF WATER EMULSIFIED WITH DIESEL BY SURFACTANT ADDITION ON PERFORMANCE AND EMISSION CHARACTERISTICS OF DIESEL ENGINE

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ABSTRACT

Diesel engines are very well known to emit gaseous emission and particulate matter. So it had long been regarded as one of the major air pollution sources, particularly in metropolitan areas, and has been a source of serious public concern for a long time which is very clear with the proposal of ban on registration of diesel SUVs and high-end vehicles with engine capacity of over 2000 cc in major city of India. So definitely there have been numerous researches in the field of reduction of these pollutants since diesel engines came to major use in transportation sector.

Using emulsion of diesel in water as a fuel has been a recent field of study to reduce emissions from diesel engine. Water/diesel (W/D) emulsified formulations are reported to reduce the emissions of NO_x, SO_x, CO and particulate matter (PM) without compensating the engine's performance. In this paper a new kind of emulsion is prepared by mixed surfactant method, major concern being the long term stability of the same. Then performance and emission tests were carried out by using the fuel in a two cylinder water cooled diesel engine. The results were matched against that of diesel and comparison graphs were plotted to see what are the advantages and disadvantages of using the emulsion over diesel.

Key words: Emissions, Emulsion, Reduction, Surfactant, Water.

INTRODUCTION

Internal combustion engines generate undesirable emissions during the combustion process. The pollutants that are exhausted from the internal combustion engines affect the atmosphere and cause problems such as global warming, smog, acid rain, respiratory hazards etc. These emissions are mostly due to nonstoichiometric combustion, dissociation of

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nitrogen and impurities in the fuel and air. Major emissions include Nitrogen Oxides (NOx), unburnt Hydrocarbons (HC), oxides of Carbon, oxides of Sulphur and other carbon particles or soot. There are various ways to treat these pollutants. Two major ways are –treatment inside the cylinder and after treatment or treatment outside the cylinder. In this project an emulsion is prepared, which replaces the diesel fuel meant for the engine, and the emission and performance parameters are studied.

Diesel water emulsions

Diesel water emulsions have come into recent field of study. When mixed directly, diesel being a lighter liquid than water comes to the top and water settles in the bottom. By using an appropriate surfactant the molecules of water and diesel can be bound together. The stability of the emulsion made is very important, because if it's not stable for an appreciable period of time it won't be practically useful. Using water mixing agent with diesel has many benefits on its own. It has been shown in many previous researches that it reduces the flame temperature thereby reducing the NOx emissions significantly. Addition of water also improves atomization and mixing which is attributed to droplet micro emulsion. The improved mixing is due to the increased vaporized jet fuel momentum giving air more way to get into the fuel jet. This also assists in reduction in NOx from diffusive burning portion of combustion event as well as reducing the carbon formation. This effect along with the chemical effect of water results in increase in ignition delay. There is also a considerable proof that adding water to diesel can reduce the particulates and smoke emission. There has been a growing interest in diesel fuel industry to produce and utilize the diesel water emulsion as usable fuels for diesel engines. Fuel additive manufacturers try to make diesel oil and water oil mix, or can be neighbourly enough to form pollution cutting diesel fuel. There have been several trials done to produce a stable emulsion which will stay the same way for a long period of time. If the emulsion remains still for many days, larger droplets of chemically coated water may settle to the bottom of the tank, or it's also been seen that coagulated particles settle down in the bottom of the tank. The fuel, however, will mx again if agitated slightly, and thus the tank is re filled to mix it again. The influence of water on some of the performance parameters, exhaust emission of diesel engine has been studied by many works. However its effect on the heat flux crossing the combustion chamber components i.e. cylinder heads and cylinder liners, chamber metal temperature and thermal loading in such engines is still under study.

Reduction of NOx is originated from the reduction of local high temperature due to vaporized water during combustion. The reduction of local high temperature may cause the

reduction of reaction rate, which has a possibility of affording a mixing time for better combustion for reducing PM. Micro-explosion, considered as the second atomization, improves fuel combustion and reduces fuel consumption.

The experimental result indicates the both methods (emulsion and injection) could reduce NO emission drastically in diesel engines. At full load, NO emission decreased drastically from 1034 ppm with base diesel to 645 ppm with emulsion and 643 ppm with injection. But, NO emission reduction is lesser with injection than emulsion at part loads. Smoke emission is lower with the emulsion (2.7 BSU) than with water injection (3.2 BSU) as compared to base diesel (3.6 BSU). However, CO and HC levels were higher with emulsion than water injection.

The results showed that when engine load was 180 Nm with the conditions of 0% to 20% water emulsion ratio and 21% to 21.5% intake oxygen concentration, as well as under the condition of 100% load with 10% to 15% water emulsion ratio and 21% to 22% intake oxygen concentration, the NO-Smoke emissions were lower than that of original engine and BSFC was not exceeding 5% of the original engine by optimized combination of water emulsion ratio and oxygen concentration.

Results reported here suggest that the water emulsification has a potential to slightly improve the brake efficiency and to significantly reduce the formation of thermal NO, soot, hydrocarbons and PM in the Diesel engine.

The results showed that emulsions with large size of water droplets resulted in greater reduction in NOx emissions up to 25%. While, emulsions with finer droplets not only gave reductions in engine smoke and unburned hydrocarbons of values greater than 80% and 35% respectively, but also resulted in an increase of the engine effective efficiency of 20%.

The results showed that adding small amounts of water 2%, to neat diesel fuel produced a significant increase in the engine power. Furthermore, its engine torque and noise emission were comparable with those of neat diesel fuel. The higher water addition to diesel decreased the engine power and torque, however no such change was found for the engine noise emission.

Results reported here suggest that the water emulsification has a probable to improve brake thermal efficiency and break specific fuel consumption. Emulsions of diesel and water

are often promoted as being able to overcome the difficulty of simultaneously reducing emissions of both oxides of nitrogen (NOx) and hydro carbon emissions in a diesel engine.

Water in diesel emulsion

Water in diesel emulsion comes under the category of water in oil emulsion. The surfactant that has to be used should have an HLB (Hydrophilic Lipophilic Balance) value in the range of 7 to 11. One surfactant with this value can be used otherwise mixed surfactant can be used. In the latter case the two surfactants should be chosen carefully so that one is hydrophilic and other is lipophilic. In this experiment a mixed surfactant is made and has been used.

Methodology and experiment set-up

Preparation of emulsion

Components required for making emulsion are: Mechanical agitator, diesel, distilled water, Burette and pipette.

1. The pipette, burette and container were thoroughly washed and cleaned dry.
2. Diesel was measured in the burette in required volume and poured into container. Now calculated volume of each surfactant were measured in the pipette and poured into the container. Same done for water.
3. Now the container is placed under the mechanical agitator and the mixture is thoroughly mixed for about 10-15 min.
4. The emulsion thus obtained is checked for stability.

Emulsified samples:

Table 1: Emulsified samples data

Emulsion (/100 mL)	Diesel (%)	Water (%)	Tween 20 (%) [Surfactant]	Span 20 (%) [Surfactant]
Sample 1	90	8	0.5	1.5
Sample 2	88	10	0.5	1.5
Sample 3	83	15	0.5	1.5
Sample 4	78	20	0.5	1.5

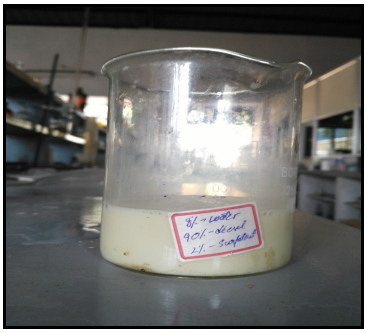

Fig. 1: Emulsified diesel sample

Properties of the emulsified diesel was evaluated and they are shown in following Table.

Table 2:

Fuel	Flash point (^{o}C)	Fire point (^{o}C)	Density (Kg/m^{3})
Pure diesel	55	59	0.833
Emulsion 1 (8% water)	58	61	0.84150
Emulsion 2 (10% water)	56	61	0.82848
Emulsion 3 (15% water)	63	65	0.841574
Emulsion 4 (20% water)	53	58	0.855646

Engine specifications

Kirloskar diesel engine, single cylinder, vertical water cooled, 3.5 KW @ 1500 rpm. Compression ratio = 16.5:1, Rope brake dynamometer, Fuel measuring device, Stop watch scale and spring balance.

Fig. 2: Engine set up

RESULTS AND DISCUSSION

All the engine performance parameters are calculated and graphs are plotted with reference to brake power.

Results are discussed below.

Brake thermal efficiency

Brake thermal efficiency increases with increase in load. It can be seen that it increases linearly for diesel. Whereas for the emulsions it increases initially till a load and then decreases. But it can be observed that BTE for emulsion with 8% water concentration is higher than that of diesel even at very high loads, this is because addition of water improves atomization and mixing which is attributed to droplet micro emulsion. So emulsions prove out to be better fuels when BTE is concerned.

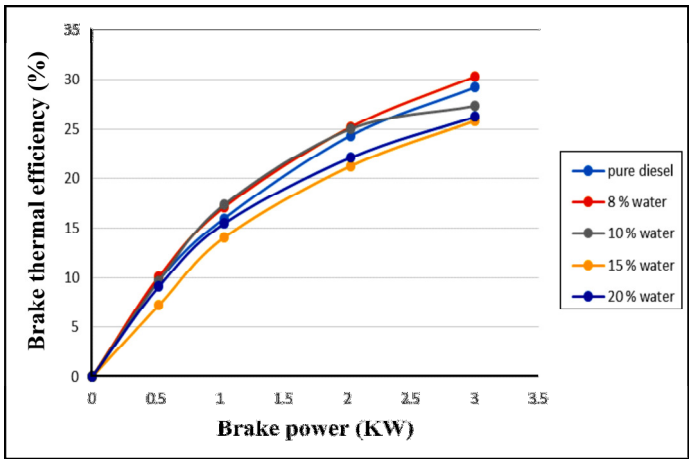

Fig. 3: Brake thermal efficiency vs. brake power

Brake specific fuel consumption

It is seen from the graph that the Bsfc of the engine increases when emulsion is used, but it also depends on the concentration water in the emulsion. It decreases up to a certain limit and then again increases. The Bsfc is best obtained for the emulsion with 8% and 10% of water. Use of water increases the combustion efficiency of the engine by keeping the temperature in the working range. After a certain point when volume of water increases more, it inhibits the combustion.

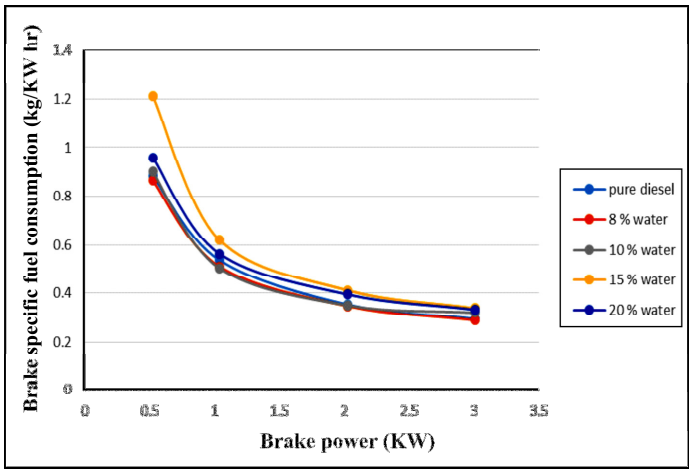

Fig. 4: Specific fuel consumption vs. brake power

Carbon monoxide

Carbon monoxide is emitted as a result of incomplete combustion of carbon and oxygen under high temperature inside the cylinder. With increase in load CO emission increases for all the fuels used. It has been observed that emission of CO increases with increase in volume of water in the emulsion. This happens because with increase in water the temperature inside the cylinder decreases slowing down the combustion of carbon, as a result of which incomplete combustion occurs.

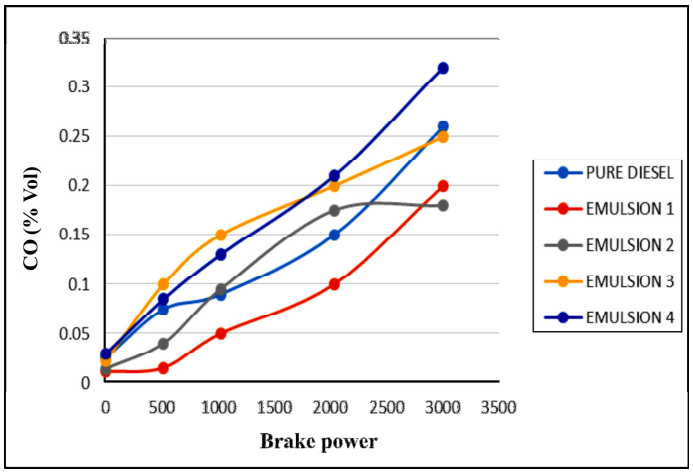

Fig. 5: Carbon monoxide emission vs. brake power

Nitrogen dioxide (Nox)

Exhaust gases of an engine can have up to 2000 ppm of oxides of nitrogen. Most of this exhaust contains nitrogen oxide (NO) with small amount of dioxide. With increase in load NOx emission increases for diesel as well as other fuels. It has been observed that using diesel water emulsion as fuel greately reduces the NOx emissions as much as 38% as compared to diesel. This happens because when water along with diesel enters the combustion cylinder, it is directly vaporized into steam due to presence of high temperature and pressure inside the cylinder. This takes some of the heat from the combustion chamber and brings down the cylinder temperature. As a result the conversion of diatomic hydrogen to more reactive monoatomic nitrogen decreases thereby reducing the chances of formation of NOx.

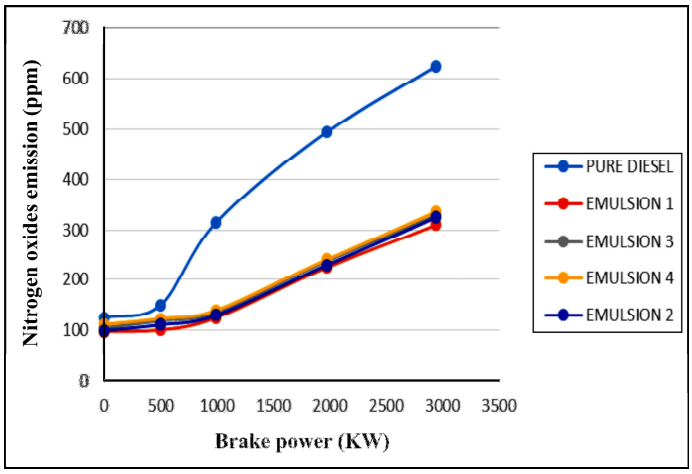

Fig. 6: Nitrogen oxides emission vs. brake power

CONCLUSION

From the above experimentation following observations can be derived:

(i) The specific fuel consumption was observed to decrease with increase in the percentage of water in diesel. Results show that specific fuel consumption is decreased by 2% to 3% when concentration of water is increased from 8% to 10%, but further increase may increase the specific fuel consumption. However at higher loads the fuel consumption is more for emulsions than diesel.

(ii) The brake thermal efficiency of the engine increase with increase in water

content in emulsion under low load condition. But it decreases at higher loads except 8% water emulsion for which brake thermal efficiency obtained was greater than pure diesel even at high loads.

(iii) The NOx emission are reduced by 38% by use of diesel water emulsion. This trend was observed to go on increasing with increase in amount of water in the emulsion. But higher water emulsification will result in depraved performance of engine.

(iv) Carbon monoxide emissions increase with increase in water percentage in the fuel. This is due to the fact that most of the hydrocarbons are burnt at lower loads.

From the above observations, it can be concluded that use of diesel water emulsion with 8% water content will have the best results in terms of performance as well as emissions from diesel engine due to better chemical properties of that particular fuel.

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Revised : 22.11.2016 *Accepted : 25.11.2016*