Effect of Hydro Emulsification in Diesel Engine

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Abstract -Diesel engines exhausting gaseous emission and particulate matter have long been regarded as one of the major air pollution sources Major emissions from a diesel engine are Nitrogen oxide, carbon monoxide, Hydro carbon and particulate matter. Amongst these pollutants carbon monoxide and some quantity of particulate matters are reduced by some after treatment methods, outside the engine, in the catalytic converter etc. unlike these Nitrogen oxides can't be oxidized to get some clean product. Nowadays Nitrogen oxide emissions are reduced by selective catalytic reduction. Using an emulsion of diesel in water as a fuel has been a recent field of study in this field. Water/diesel emulsified formulations are reported to reduce the emissions of Nitrogen oxide, carbon monoxide and particulate matter without compensating the engine's performance. In this project 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 single cylinder 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.

Keywords—*Diesel, Efficiency, Emission, Emulsion, Polysorbate 20, Sorbitan monolaurate20*

1. 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 non stoichiometric combustion, dissociation of nitrogen and impurities in the fuel and air .Major emissions include Nitrogen Oxides, unburnt Hydrocarbons, oxides of Carbon 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. [6]

The objective of this project is to create a new fuel that can be used in a diesel engine as a fuel. The fuel is created by making an emulsion of diesel and water by using a suitable surfactant. The emulsion has to be stable for a longer period of time. Then the engine is run with regular diesel fuel and same observations are taken. A comparison is done between the two cases in terms of performance and emission properties of the fuel.

2. DIESEL WATER EMULSION

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 Nitrogen oxide emissions significantly. Addition of water also improves atomization and mixing which is attributed to droplet micro emulsion. [2] This also assists in reduction in Nitrogen oxide 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 neighborly 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 mix again if agitated slightly, and thus the tank is refueled to mix it again.[3]

3. SURFACTANTS

Surfactants are compounds that lower the surface tension of a liquid that is it decreases the interfacial tension between two liquids, or that between a liquid and a solid. Surfactants may act as detergents, wetting agents, emulsifiers, foaming agents and dispersants. In this experiment the role of surfactant is as an emulsifier. For emulsification process one of the biggest challenges is choosing the right surfactant for the two liquids to be emulsified. This depends on the HLB value of the surfactant. HLB i.e. the Hydrophilic Lipophilic

Balance is the measure of degree to which it is hydrophilic or lipophilic. [9]

Table-1 Surfactant types

Surfactant	HLB value
Sorbitan trioleate	1.8
Sorbitan monooleate	4.3
Sorbitan monostearate	4.7
Sorbitan monopalmitate	6.7
Sorbitan monolaurate	8.6
Polyoxyethylene sorbitan trioleate	11
Polysorbate 60	14.9
Polysorbate 80	15
Polysorbate 40	15.6
Polysorbate 20	16.7

4. TYPES OF EMULSIONS

Depending upon the nature of the dispersed phase and dispersing medium, the emulsions are classified into two types: [10]

4.1. Oil-in water emulsions (O/W):

The emulsions where oil is the dispersed phase and water is present as the dispersion medium (continuous phase) is called oil in water emulsion. Milk is an example of oil in water emulsion. In milk fat globules are dispersed within water.

4.2. Water – in - oil emulsions (W/O):

The emulsion in which water forms the dispersed phase and the oil is present as a dispersing medium (continuous phase) is called water in oil emulsion. They are also termed as oil emulsions. Butter, cold cream, cod liver oil etc. are examples of this emulsion.

Depending on the size of the droplets, the emulsions are classified into two types:

A. Macro emulsions:

The size particles ranges from 0.2 to 50 mm. they are kinetically stable. [5]

B. Micro emulsions:

The size of the particles ranges from 0.01 to 0.02 mm. they are thermodynamically stable. [5]

Table-2 Emulsion Types

HLB value	Type of emulsion
<10	Lipid soluble (water insoluble)
>10	Water soluble
4 to 8	Antifoaming agent
7 to 11	Water in oil emulsifier
12 to 16	Oil in water emulsifier
11 to 14	Wetting agent
12 to 15	Detergents
16 to 20	Solubilize and hydro trope

5. PREPARATION OF EMULSION

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

a) The pipette, burette and container were thoroughly washed and cleaned dry.
b) 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.
c) Now the container is placed under the mechanical agitator and the mixture is thoroughly mixed for about 10-15 minutes.
d) The emulsion thus obtained is checked for stability.

Various trials were carried out before obtaining a stable emulsion

5.1. Trial 1:

94 % diesel + 5% water + 1% tween 20:

The emulsion was not stable after 1 hour. There was a visible distinct layer of water underneath diesel. Hence emulsion was not stable.

Fig 1: Trial 1

5.2. Trial 2:

94 % diesel + 5% water + 1% span 20:

The emulsion was not stable after sometime. Some milky globs were formed which settled down the container. Hence this was also rejected.

Fig 2: Trial 2

5.3. Trial 3:

94 % diesel + 5% water + 0.5% tween 20 + 0.5% span 20:
Here a stable emulsion was obtained. The emulsion was milky white in colour and remained as it is for a very long period of time. This was used in the experiment as the new fuel.

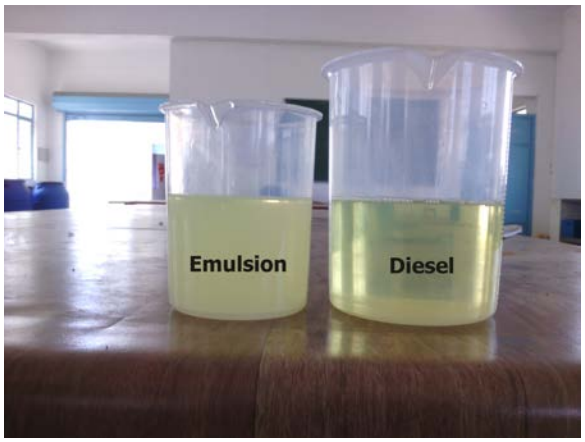

Fig 3:Final Emulsion

6. PROCEDURE

a) The fuel tank was then filled with diesel and the engine was run.
b) The engine was run at various loads of the dynamometer 1, 2, 3, 4 kgs and respective readings were taken for fuel consumption/ sec.
c) The readings of gas analyzer were noted in each case.
d) After all the readings were taken, the leftover diesel was drained out of the tank and emulsion was poured.
e) Same steps were taken and the readings were noted down for the emulsion.
f) Before using the next emulsion the engine was again run with diesel so that the results are not biased.
g) After taking all the observations graphs were plotted to compare the performance characteristics and emission characteristics of the engine in case of diesel and emulsion.

7. RESULTS AND DISCUSSIONS:

7.1. Performance characteristics:

7.1.1. Specific fuel consumption:

Specific fuel consumption of an engine is defined as the amount of fuel used per load per second. This is an important performance parameter as it determines the mileage of the vehicle. In practical purposes this very important aspect a consumer looks for, as it determines whether the product is value for money or not

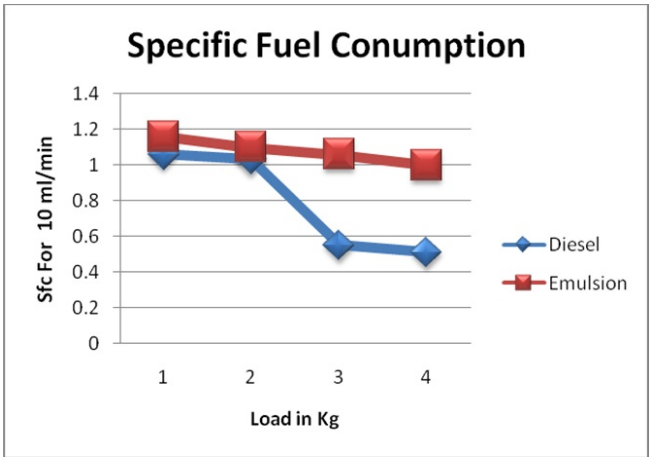

Fig 4: Specific Fuel Consumption

7.1.2. Mechanical Efficiency:

The mechanical efficiency of both diesel and emulsion are more or less equal. The performance had not compensated when compared to diesel

7.2. Emission characteristics:

7.2.1. 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.

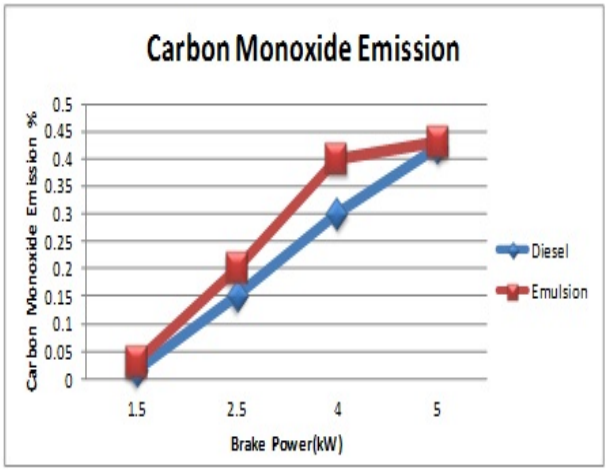

Fig 5: Carbon monoxide emission

7.2.2. Hydrocarbon Emission:

Exhaust gases leaving the combustion chamber of a diesel engine contains up to 100 ppm of hydrocarbon. These consist of small non equilibrium which is formed when large fuel molecules break up during the combustion reaction. It is often convenient to treat these molecules as if they contained carbon atom. It is seen that HC emissions increases up to a certain load then decreases for diesel. For the emulsions it shows increasing trend as the load increases. Under lower

load conditions emission in case of diesel is more than that of emulsions but at higher load conditions the emulsions give more HC emissions than diesel.

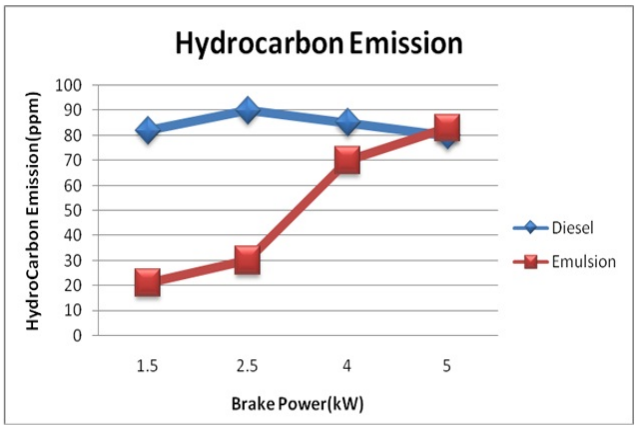

Fig 6: Hydrocarbon emission

7.2.3. Carbon dioxide emission:

Carbon dioxide comes as exhaust as a result of complete combustion of carbon particles in the fuel and the combustion of CO inside the cylinder. For diesel it increases linearly with increase in load. For the emulsions too it increases linearly with some variations at some loads. CO2 emission increases when we add water to diesel. With increase in the percentage of water in diesel CO2 emission increases.

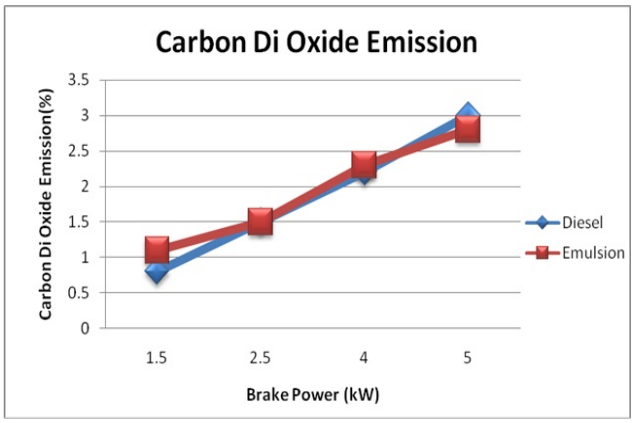

Fig 7: Carbon dioxide emission

7.2.4. Nitrogen oxide emission:

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 Nitrogen oxide is very undesirable as it has many adverse effects on the environment. With increase in load Nitrogen oxide emission increases for diesel as well as other fuels. It has been observed that using diesel water emulsion as fuel greatly reduces the Nitrogen oxide emissions 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.

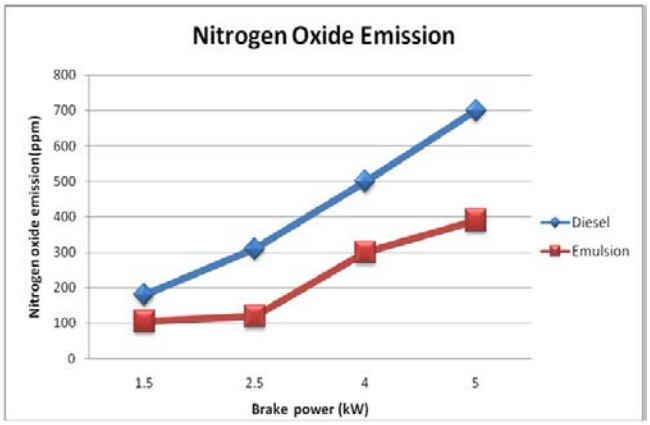

Fig 8: Nitrogen oxide emission

8. CONCLUSIONS

a) The specific fuel consumption was observed to decrease with increase in the percentage of water in diesel. However at higher loads the fuel consumption is more for emulsions than diesel.
b) The mechanical efficiency of both Diesel and emulsion are same at a given load, Hence 1 to 2% deviation.
c) The Nitrogen oxide emission is brought down by 20% - 40 % by use of diesel water emulsion. This trend goes on increasing with increase in amount of water in the emulsion.
d) At lower loads the hydrocarbon emissions are lesser for emulsion as compared to diesel; however when the load increases HC emissions are higher for emulsions.
e) Carbon monoxide and carbon dioxide 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.
f) For optimal results use of diesel water emulsion with 5% water content will Positive the best results in terms of performance and emissions.

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