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A RESEACH TO OPTIMIZE THE ENGINE-OUT EMISSIONS FROM A DIESEL CRDI ENGINE TO MEET EUROPE STAGE 3B EMISSION LIMIT USING SELECTIVE CATALYTIC REDUCTION (SCR)

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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, particularly in metropolitan areas, and have been a source of serious public concern for a long time. There has been numerous research in the field of reduction of these pollutants since diesel engines came to major use. Major emissions from a diesel engine are NOx, SOx, CO and particulate matter (PM).amongst these pollutants CO and Sox and some quantity of particulate matters are reduced by some after treatment methods, outside the engine, in the catalytic converter etc. unlike these NOx can't be oxidized to get some clean product. Nowadays NOx 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 (W/D) emulsified formulations are reported to reduce the emissions of NOx, SOx, CO and particulate matter (PM) 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.

KEYWORDS: Emission, Diesel Engine, NOx, Sox, CO, SCR

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 nonstoichiometric combustion, dissociation of 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.

Emissions from diesel engines:

Diesel engines have been used in heavy duty applications for a very long time now; it is only recently that it has become very popular in light duty application due to their higher fuel efficiency. Higher fuel efficiency in the diesel engines is achieved due to the high compression ratios along with high oxygen concentration in the combustion chamber. However, these same factors results in high NOx emission in diesel engine. The main pollutants of diesel engines are NOx and particulate matter (PM). The mechanism of formation of Nitrogen oxides and particulate matter inside the combustion chamber of diesel engines are contradictory and the simultaneous reduction of both at the same time is very difficult [1]. Researchers have Attempted to reduce the emissions and improve the fuel efficiency of diesel engines. Diesel engines have been used in heavy duty applications for a long time; it is only during the past decade that it has become very popular in light duty application due to their high fuel efficiency. Higher fuel efficiency in the diesel engine is achieved because of the high compression ratios along with relatively higher oxygen concentration in the combustion chamber.

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However, these same factors results in higher NOx emission in diesel engine. The stringent emission norms have been an important driving force to develop the internal combustion engines in a more environment friendly way. The main pollutants from diesel engines are NOx and particulate matter (PM). The mechanism of formation of NOx and particulate matter in the combustion chamber of diesel engines are contradictory and the simultaneous reduction of both is very difficult [1]. Researchers have attempted to reduce the emissions and improve the fuel conversion efficiency of diesel engines.

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 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 mx again if agitated slightly, and thus the tank is refueled to mix it again.

2. EXPERIMENTATION

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

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

Various trials were carried out before obtaining a stable emulsion:

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.

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.

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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. Same surfactants were used to make another emulsion by varying quantities of water and diesel.

Properties of the fuel:

Density: 831 kg/m3

Calorific value: 41380kJ/kg

Figure 1: emulsion 1

Figure 2 : emulsion 2

Figure 3 : emulsion 3

Figure 1: emulsion 1

Engine specifications and apparatus:

Comet diesel engine, twin cylinder, vertical water cooled, 7.5 KW @ 1500rpm. Compression ratio = 17.5, Eddy current dynamometer, Fuel measuring device, Stop watch scale and, Spring balance

Figure 4: Engine Set Up

AVL gas analyzer and smoke metere:

Gas analyzer and smoke meter are used to measure the exhaust gases coming out from the engine. The AVL gas analyzer measure CO2, CO, HC, O2 and NOx coming out of the engine. It measures the standard values of these emissions.

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Mechanical agitator:
This is used to thoroughly mix the mixture and form the emulsion. It consists of a motor which is used to rotate the blades which is dipped in the mixture. There is speed control knob to optimize the speed of the motor.

Figure 5: Mechanical Agitator

Procedure:

- The filters of the engine were replaced and the injectors were cleaned and calibrated according to the desired pressure.].
- The AVL gas analyzer and smoke meter were installed. The input to the gas analyzer was taken from the exhaust port of the engine.
- The fuel tank was then filled with diesel and the engine was run.
- The engine was run at various loads of the dynamometer – 5,10,15,20,25 kgs and respective readings were taken for fuel consumption/ sec.
- The readings of gas analyzer and smoke meter were noted in each case.
- After all the readings were taken, the leftover diesel was drained out of the tank and emulsion was poured.
- Same steps were taken and the readings were noted down for the emulsion.
- Before using the next emulsion the engine was again run with diesel so that the results are not biased.
- 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.

3. RESULTS AND DISCUSSION

Performance characteristics:
Calculation of brake power under each load condition:

BRAKE POWER $= \frac{2 * \pi * N * T}{60 * 1000}$
Where, N = rpm of the engine
T = torque.
T = S*R, S= spring weight
R = arm length.

Table -3: Brake power at different loads

LOAD (In KG)	BRAKE POWER (KG)
0	0
5	1.35
10	2.7
15	4.05
20	5.4

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Brake specific fuel consumption:

Brake specific fuel consumption of an engine is defined as the amount of fuel used in kgs per brake power 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.

$$\textbf{Bsfc} = \frac{Mass\ of\ fuel\ (kg)}{bp\ (kw) * time\ (hr)}$$

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 7.5% 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.

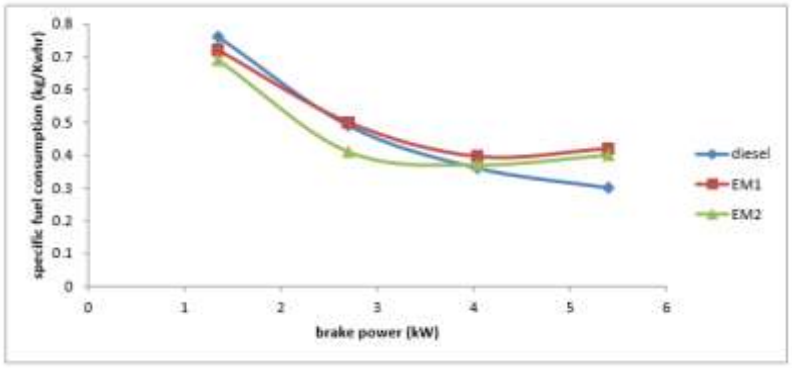

Figure 6: specific fuel consumption vs. brake power

Brake thermal efficiency:

Brake thermal efficiency of a vehicle is a very important performance parameter. It is given by

$$\textbf{BTE} = \frac{bp}{Calorific\ value * fuel\ consumption\ per\ sec}$$

It 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 emulsions are always higher than that of diesel except at very high loads. So emulsions prove out to be better fuels when bte is concerned.

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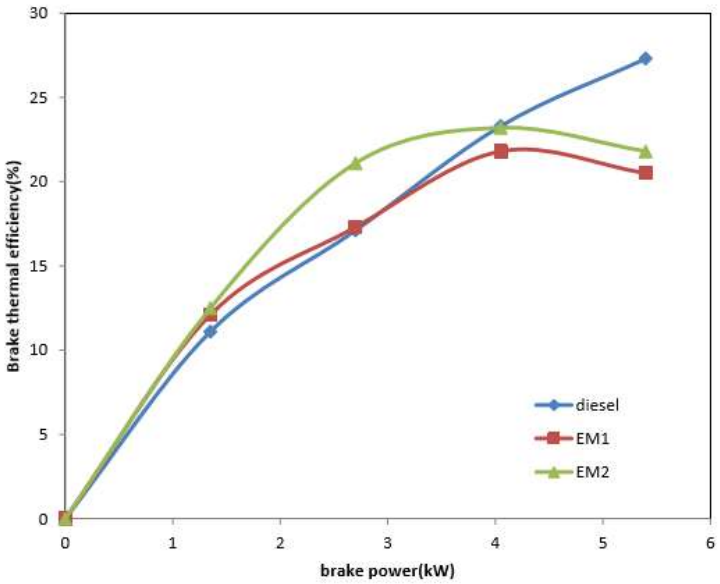

Figure 7: Brake thermal efficiency vs. brake power

4. CONCLUSION

- The specific fuel consumption was observed to decrease with increase in the percentage of waterin diesel. Results show that specific fuel consumption is decreased by 2% to 3 %when concentration of water is increased from 5 % to 7.5 %, but further increase may increase the specific fuel consumption. However at higher loads the fuel consumption is more for emulsions than diesel.
- The brake thermal efficiency of the increases with increase in water content emulsion under low load condition. But it decreases at higher loads.
- The NOx emission is brought down by 30% - 50 % by use of diesel water emulsion. This trend goes on increasing with increase in amount of water in the emulsion.
- 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.

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