IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 5 Ver. V (Sep. - Oct. 2015), PP 29-34
www.iosrjournals.org

Impact of Emulsified Water&Diesel Mixture on Engine Performance and Environment

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Abstract: *This paper reports on producing a stable diesel-water emulsion fuel to be used in a diesel engine under constant speed and different load conditions. The proper mixing technique and emulsifying agent were used to produce stable emulsions of 3%,5%and 7% water by volume in diesel. The stability of these emulsions ranges from 1 week to 4weeks.The effect of water-diesel concentration , on the performance of a single cylinder four stroke diesel engine in terms of engine speed , brake power output, specific fuel consumption , total fuel consumption , brake thermal efficiency , mechanical efficiency indicated thermal efficiency.*

I. Introduction

Improving internal combustion (IC) engine efficiency is a prime concern today. A lot of engineering research has gone into the improvement of the thermal efficiency of the (IC) engines, so as to get more work from the same amount of fuel burnt and the energy present in the combustion chamber only a portion gets converted in to useful output power. Diesel engines have been used in heavy duty applications for a long time; it is only during the past decade that it has become popular in light duty application due to their higher fuel efficiency. Higher fuel efficiency in the diesel engine is achieved due to the high compression ratios along with relatively high oxygen concentration in the combustion chamber. However, these same factors results in high NOx emission in diesel engine.[1]. Researchers have attempted to reduce the emission and improve the fuel conversion efficiency of diesel engines. One promising method may be the use of water emulsified diesel which can economically accomplish both of these goals. In the water emulsified diesel, the droplet size of the emulsion fuel is one of the most important factors determining the subsequent combustion characteristics [2]. The proven benefit of the water emulsified diesel is that the heat absorption by water vaporization causes a decrease of local adiabatic flame temperature and therefore reduces the chemical reaction in gas phase to produce thermal NO [4]. Fuel with a larger emulsion ratio results in a longer ignition delay and a longer premixed combustion phase.[5]. The diesel internal combustion engine differs from the gasoline powered Otto cycle by using highly compressed hot air to ignite the fuel rather than using a spark plug . In the true diesel engine, only air is initially introduced into the combustion chamber. The air is then compressed with a compression ratio typically between 15:1 and 22:1 resulting in 40-bar (4.0 MPa; 580 psi) pressure compared to 8 to 14 bars (0.80 to 1.40 MPa; 120 to 200 psi) in the petrol engine.

Emulsions

An emulsion is a mixture of two or more liquids that are normally (nonmixable or unblendable). Emulsions are part of a more general class of two-phase systems of matter called collides. Although the terms *colloid* and *emulsion* are sometimes used interchangeably, *emulsion* should be used when both the dispersed and the continuous phase are liquids. In an emulsion,one liquid (the dispersed phase) in the other (the continous phase).examples of emulsions include vinaigrattes, milk, mayonnaise and some cutting fluids for metal working.

Surfactants:

Surfactants are compounds that lower the surface tension (or interfacial tension) between two liquids or between a liquid and a solid. Surfactants may act as detergents wetting agents, emulsifiers, foaming agents , and dispersants. In solution, detergents help solubilize a variety of chemical species by dissociating aggregates and unfolding proteins. Popular surfactants in the biochemistry laboratory are SDS and CTAB. Detergents are key reagents to extract protein by lysis of the cells and tissues: They disorganize the membrane's lipidic bilayer (SDSTritonX-100)

Fig.1.TritanX-100& diesel

Experimental Procedure

Diesel engine setup:

In this project we are using the single cylinder four stroke diesel engine. Several samples of emulsified Diesel-Water fuel were prepared to be compared with pure Diesel and Diesel with surfactant only, to study the impact of emulsified fuel on engine performance and emissions of the diesel engine exhaust gaseous. The engine specifications are listed in the below Table

Engine Specifications

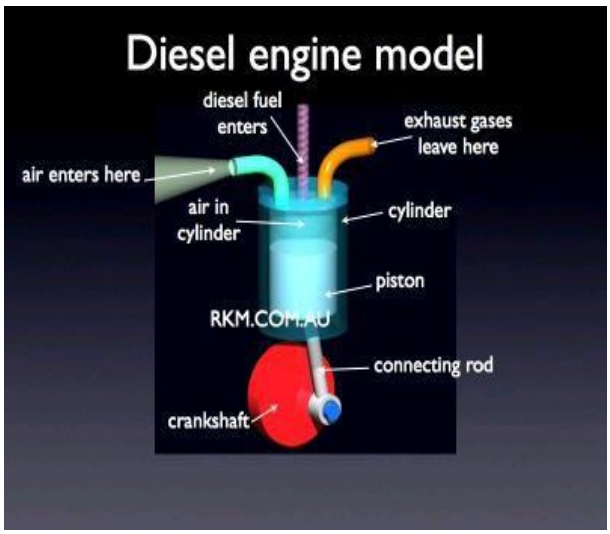

Fig.2.Diesel engine model

The engine Performance analysis has included the following features: specific fuel consumption, brake horsepower, total fuel consumption, and brake thermal efficiency mechanical efficiency and indicated thermal efficiency. Whereas, the NOx emission analysis is studied on a four stroke single cylinder direct injection engine.

Samples preparation:

Five blends were prepared to test the engine performance, and NOx emission. These blends were:
Pure diesel,
Diesel with surfactant only,
Diesel with surfactant and 3% water, Diesel with surfactant and 5% water,
Three samples were tested for each blend to validate the results. The experimental error was recorded to be in the range of ± 8 %. All tests are carried out at constant and variable engine speed starting from 1000 rpm up to 1500 rpm for the performance evaluation.

Emissions:

The lean-burning nature of diesel engines and the high temperatures and pressures of the combustion process result in significant production of nitrogen oxides, and provide a unique challenge in reducing these compounds. Modern on-road diesel engines typically uses elective catalytic reduction to meet emissions laws, as other methods such as exhaust gas recirculation cannot adequately reduce NOx to meet

Engine	Single cylinder 4-stroke diesel engine
Type	Water cooled
Bore	80mm
Stroke	110mm
BHP	5
Compression ratio	16.5 : 1
Dynamometer	AC alternator
Capacity	4KW
Armature voltage	220V
Radius of dynamometer	215mm
Efficiency of dynamometer	80%

Newer standards in many jurisdictions. However, the fine particulate matter (sometimes visible as opaque dark-colored smoke) has traditionally been of greater concern in the realm of diesel exhaust, as it presents different health concerns and is rarely produced in significant quantities by spark-plug ignition. Diesel engines produce very little carbon monoxide as they burn the fuel in excess air even at full load, at which point the quantity of fuel injected per cycle is still about 50 percent lean of stoichiometric.

The water emulsified diesel fuel was prepared by mixing 3% ,5% and 7% of distilled water with 97% ,95% and 93% of diesel by volume, respectively. Triton X-100 was used as surfactant to prepare emulsion. . Triton X-100 is added with 10 ml and 15 ml distilled water and mixed with 970 ml, 950 ml and 930 ml diesel to prepare emulsified diesel fuels, respectively. The mixer was stirred for 2-3 minutes in an electrically operated agitator. The experiments were performed at constant speed of 1500 rpm. The engine was loaded by eddy current dynamometer and the load was measured using a strain gauge. The air consumption is measured with an air manometer surge tank set which has orifice diameter of 20 mm.

II. Results

The aim of the experimental study was to investigate the effect of diesel, diesel with 3% water and diesel with 5% and 7% water performance and emission in a light duty single cylinder diesel engine. The experimental results are presented in Figures .

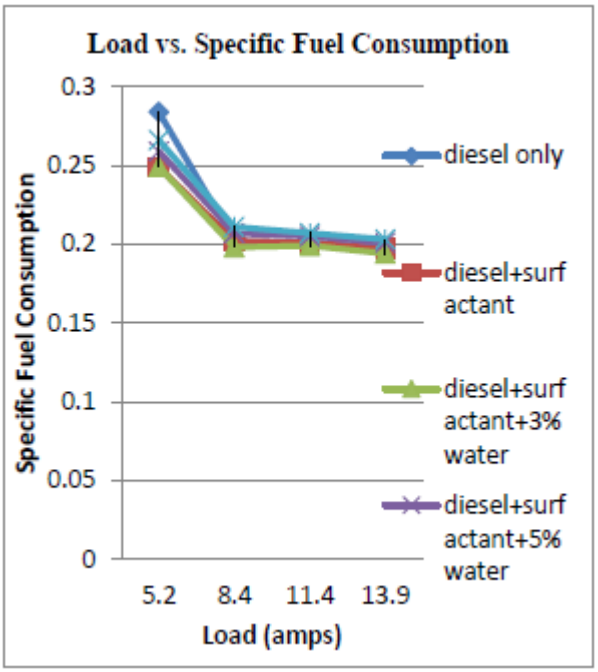

Fig.3. Load vs. Specific Fuel Consumption

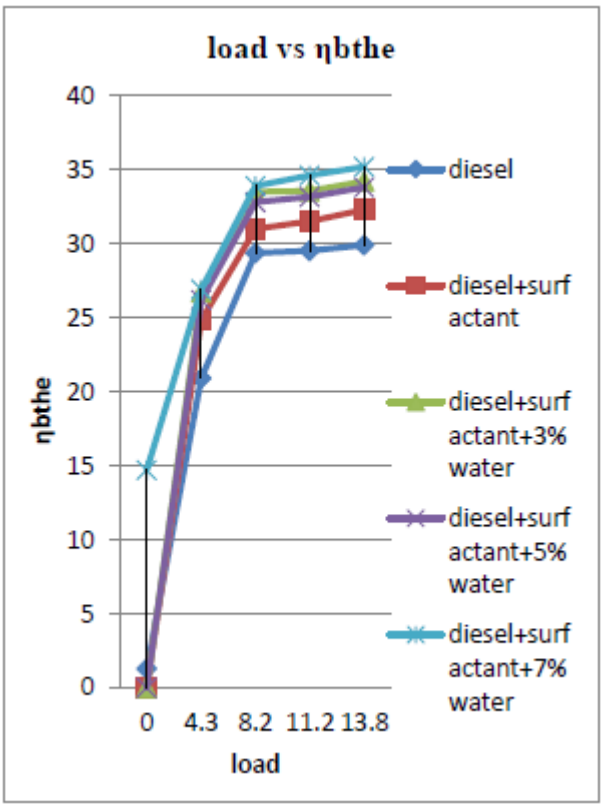

Fig.4. Load Vs Brake thermal efficiency

The brake specific fuel consumption (BSFC) decreases at all load conditions when the percentage of water in the emulsion is increased as shown in Figure-3. As the percentage of water in the emulsion increases, the amount of diesel is replaced by an equal amount of water. This means that less diesel fuel is actually contained in unit volume of the emulsion. So, as the percentage of water in the emulsion increases, the BSFC decreases. The minimum value occurs when the percentage of water is 5 % [3]. When the emulsified fuel is used, the most probable reason to obtain improvement in brake specific fuel consumption and thermal efficiency is the reduction of heat losses [4].

The effect of water percentage in diesel-water emulsion on brake thermal efficiency is shown in Figure-4. When the amount of water in the emulsion increases the brake thermal efficiency increases. The presence of water in the emulsion increases the expansion work and reduces the compression work resulting increased net work done during the cycle.

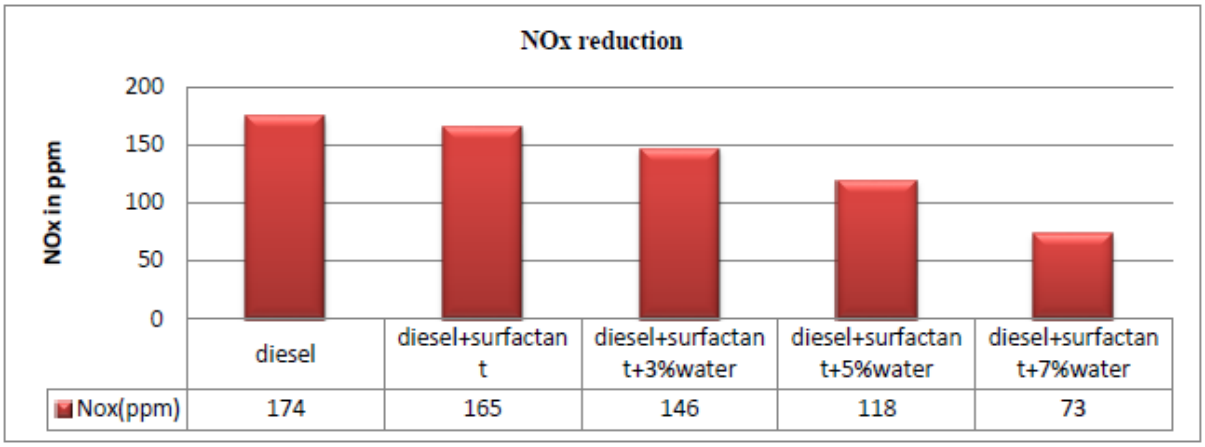

Fig.5. NOx reduction

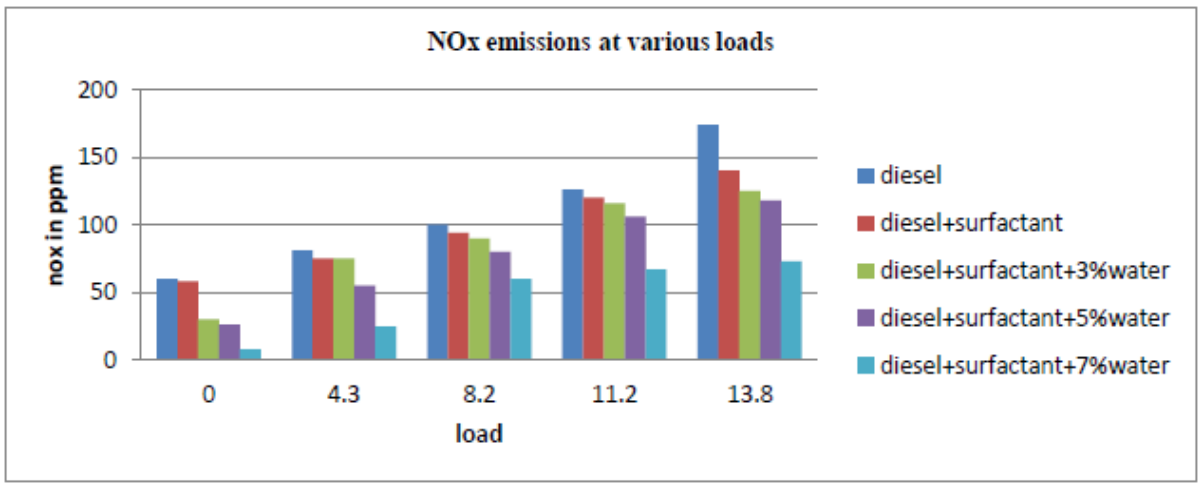

Fig.6. NOx emissions at various loads

The NOx emission decreases with the percentage of water in the emulsion as shown in Figure-6 at all load conditions. The percentage of reduction in NOx is 10% and 25% for 3% and 5% water in the emulsion. The improvement in the NOx emission is caused by the reduction in adiabatic flame temperature due to the vaporization and sensible heats of water. The presence of water in the emulsion weakens luminous flames and reduces the peak temperature during diffusion-controlled combustion phase which leads to a lower peak pressure and a lower level of NOx emission [5]. The presence of hydrocarbon (HC) in exhaust gases at 3% and 5% water in the emulsion is shown in Figure-4. At all load conditions the presence of HC in exhaust gases is found decreasing with increase in water percentage in the emulsion.

III. Conclusion

This present study of water-in-Diesel emulsions investigated the effect of water emulsification on the Diesel engine performance and exhaust gases emissions.The results indicated that the addition of water to diesel in the form of emulsion improves combustion efficiency . The particulate matter and NOx emissions decrease as the percentage of water in the emulsion increased to 5%. So that, the benefits of adding water to diesel fuel, results in substantial reductions in nitrogen oxides and particulates. Switching to emulsified fuel combustion does not require any engine modification. The corrosion of engine components due to water presence in the emulsion could be a problem in long run operation of the engine. But, Kweonha Park et al., [7] argued that water in the oil was quickly evaporated by micro-explosion into extremely tiny droplets; this would make the water droplets not to reach directly to the combustion chamber wall, so there would be no corrosion on the cylinder surface.

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