ISSN: 0974-2115
www.jchps.com Journal of Chemical and Pharmaceutical Sciences

Reduction of Nitrous Oxide in Diesel Engine using Diesel-Water Micro Emulsion

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ABSTRACT

In this paper four new emulsions were prepared by mixing 10% water, 0.5% tween 20 and 0.5% span 20 with diesel fuel using different aqueous metal salts, the performance and emission tests were carried out by using the fuel in a single cylinder water cooled diesel engine. The results were compared with that of diesel and comparison graphs were plotted to analyze the advantages and disadvantages of using the new emulsions over diesel. This report analyze on the effect of new emulsion fuels combustion on brake thermal efficiency, brake specific fuel consumption, oxides of nitrogen and hydrocarbon emissions. The emulsions used for analysis achieved reasonable reductions in the NOx emission from diesel engines without requiring any retrofitting of the engines and also there was no notable increase in emission of other pollutants.

KEY WORDS: Micro-Emulsions, Tween 20, Span 20, Aqueous Metal Salts, Engine Emission control.

1. INTRODUCTION

Internal combustion engines create unwanted emissions during the fuel burning process. The pollutants that are comes out from the internal combustion engines pollute the atmosphere and escalate problems such as global warming, smog, acid rain, respiratory hazards etc. These emissions are generally due to non-availability of oxygen for combustion to maintain air fuel ration, separation of nitrogen and impurities in the fuel and air. Major emission includes nitrogen oxides, unburnt hydrocarbons, oxides of carbon, oxides of sulphur and other carbon particles or soot. Diesel passenger vehicles research must lead towards 90 percent reduction in NOx and a 75 percent reduction in particulate matter to satisfy the new emission standards over the next few years. This challenge will require a carefully designed approach by adding diesel, water and additives (Anna Lif, 2006). The emissions values reduced by properly designed fuel-water emulsification is tested and accepted in the research world. The main advantage of water-fuel emulsions in diesel engines is a notable reduction in NOx emission (Dan Scarpete, 2013).

The emission reduction is achieved by two methods, one method is design changes inside the cylinder and another is outside the cylinder by the way of after treatment systems (Hrishikesh Sane, 2014). The use of emulsified fuel is particularly on its ability to reduce the burnt products inside the cylinder during power stroke (Fu, 2010). Some work reported earlier concluded that injection of water through the injector was found to decrease nitrous oxides and smoke (Prabhakar, 2010), Some emulsified fuels were able to reduce the sulfur content in higher sulfur fuels, thus, adding soda ash to the emulsifying water had reduced the smoke emissions by as much as 50% (Patricia, Strandell, 1986).

During the combustion process, water initiate the fuel atomization, which is the result of micro blast, a process of water droplets at 100ºC causes explosion due to the tension between the fuel and water vapor helping better fuel air mixture (Mohammed Yahaya Khan, 2014). Water used to delay the ignition delay during combustion, which increases the pressure rise within the engine cylinder, increasing thermal efficiency and reduces thermal stress within the engine components. Micro-explosion forms between the differences in boiling points and the continuous phase (oil) and dispersed phase (water). In a water-in-oil emulsion fuel sample mixed into the oil plus surfactant surrounded by water droplets are heated in combustion chamber and since water have lower boiling point it is start boil and become metastable and water would boil drastically (Madhu, 2007). Immediately after boiling it explode in the oil. This is known as explosive boiling of micro-explosion happened in the combustion of emulsion fuels. (Myung Geun Song, 2002). Conventional diesel fuel allows small amount of water about 0.1% (Urbina Villalba, 2000). In this work four different emulsions wree prepared which replaces the diesel fuel with four aqueous metal salt with two surfactant mixed together to form an emulsion to analyze the emission and performance parameters.

2. MATERIALS AND METHODS

The major advantage of blending is to avoid design changes in the intake and injection systems, and it is easy to implement (Amzad Hossain, 2013). Therefore, selection of good and suitable additives plays an important role to increase the solubility of emulsion. Similarly selection of surfactant is very critical to identify stable emulsions. Tween 20 and Span 20 by virtue of its desirable properties, is focused in this study to stabilize diesel and water emulsions and as an alternate fuel. Stable emulsion was obtained by 89 % diesel +10 % Water + 0.5% tween 20 + 0.5% span 20, the emulsion was white in colour and stable for a very long period of time, which was used in the experiment as the new fuel. Also, the present investigation aims at NOx control using aqueous metal salt mixed with the above fuel in diesel engine. The aqueous metal salt solution–diesel emulsion were prepared by mixing neat diesel fuel and a 1% emulsifier and 10% salt solution with concentration of 0.4 mol/dm3 (Solution = mixture of salt and distilled water). The neat fuel, emulsifier (0.5 % Tween 20 and 0.5% Span 20) was first mixed together for 15 minutes using a mechanical mixer. The salt solution was then added with neat fuel emulsifier mixtures and the blend was stirred mechanically for another period of 30 minutes to obtain the emulsion. All emulsion was prepared just before each engine test. Emulsion having the composition listed in Table 1, were prepared by using the above mentioned method.

A single-cylinder, air-cooled, direct injection diesel engine developing a power output of 5.2 kW at 1500 rpm was used. Base data was generated with standard diesel fuel subsequently, four fuel emulsions diesel with tween 20 and span 20 were prepared and tested on a diesel engine. Engine performance and emission data were used to optimize the blends for reducing emission and improving performance.

3. RESULTS AND DISCUSSION

Performance parameters: Figure.1, shows the specific fuel consumption for different emulsion and neat diesel fuels. The specific fuel consumption is decreased as the load increases. Emulsion A shows minimum fuel consumption than other emulsion and diesel fuels. At higher loads the emulsion B, C and D show poor performance that diesel and emulsion A.

Figure.2 shows the effect of different emulsion blends on the brake thermal efficiency. The maximum brake thermal efficiency occurs for emulsion A at 20% load was 15 %, and at full load it was 33 %, compared diesel 12% initially and goes on increasing to maximum of 32% at full load. All other emulsion shows very poor brake thermal efficiencies particularly at full load. Improvement in combustion, especially diffusion combustion as the oxygen concentration increases by surfactant in the fuel may be the reason for the increase in efficiency.

Emission parameters: The variation of smoke density with respective engine brake power is shown in figure.3. From the figure it is observed that the addition of emulsion, decreasing the smoke density slightly at lower loads. Therefore additives addition to diesel fuel is not considerably effective to reduction of smoke density in diesel engine. But the presence of surfactant acted in the opposite way and hence the smoke is maintained. But in the case of emulsion A, small reduction in smoke is observed at lower loads.

Figure.4 give the HC emission with different emulsions. It is observed that HC emission for emulsions are lower than neat diesel fuel. This is due to the presence of oxygen in the emulsion and water which enhances complete combustion. Here also emulsion A shows considerable reduction in HC compared to all other emulsion and diesel.

Figure.5 illustrates the NOx emission with brake power of the engine. Nitrogen oxides emissions are predominately temperature phenomena, local counteraction of oxygen and duration of combustion. It is found that initially all the emulsions NOx emission was reduced after the part load the NOx emission was increased gradually. It can be seen that NOx emissions of all blends increase more rapidly than those of sole fuel as ethanol proportion and load increase at medium and high loads because of long ignition delay and rich oxygen circumstance from the water in the mixture.

Combustion parameters: The presence of oxygen molecules increases the spray optimization and evaporation. Hence it improves the combustion process of the engine. Figure.6 and 7 illustrate cylinder pressure traces of emulsified diesel fuels. It is found that at the same engine speed and maximum load, the cylinder pressure shows greater differences for sole fuel and water with additives fuel. It can also be seen that the pressure variations of water additives fuel engine higher pressure region will change sharply as with diesel engine, but the durations of the higher pressure period is shorter than that of diesel engine.

Results show that emulsion A increases the brake thermal efficiency. Emulsions B, C and D reduces the efficiency but, still better than neat diesel at lower loads. HC emission is lower in the case of emulsion fuel. NOx reduced considerable with the emulsions than neat diesel, which is the primary objective of the work.

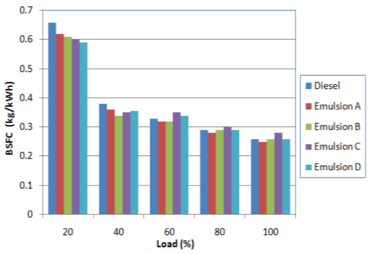

Figure.1. Variation of BSFC with load

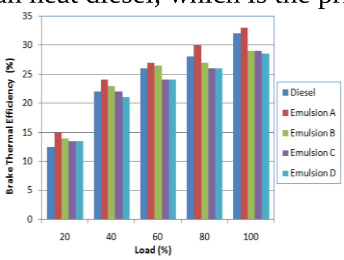

Figure.2. Variations of Brake thermal efficiency with load

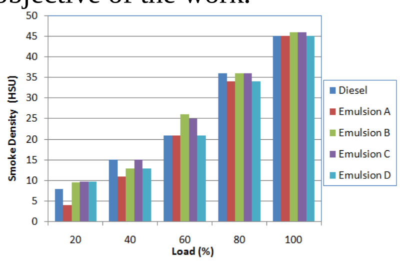

Figure.3. Variation of Smoke density with load

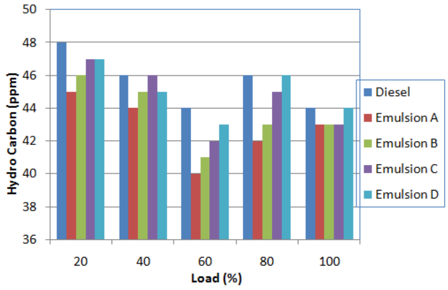
Figure.4. HC Emission with Load

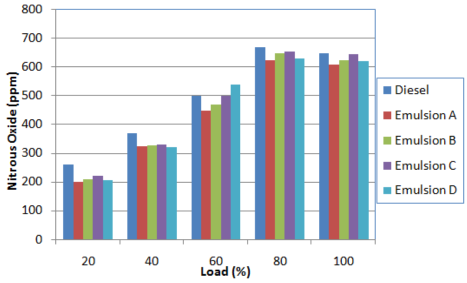
Figure.5. Variation of NOx emission with load

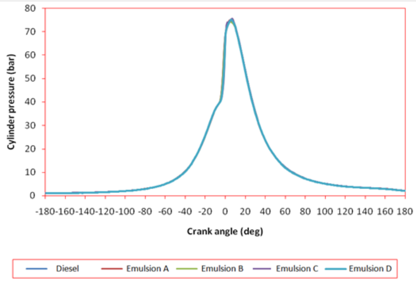
Figure.6. Variation of Cylinder pressure with crank angle

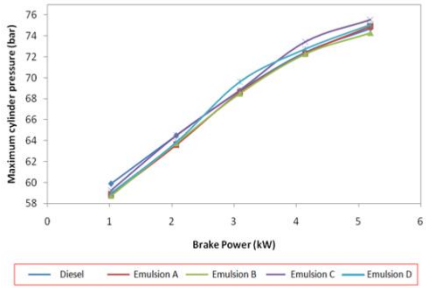
Figure.7. Variation of Maximum Cylinder pressure with BP

Table.1. Composition (% by weight)

Emulsion	Diesel	Water	Additive
Diesel	100	-	-
A	89	Sodium Formate and Distilled water - 10	1
B	89	Calcium Acetate and Distilled water-10	1
C	89	Potassium Acetate and Distilled water-10	1
D	89	Potassium Carbonate and Distilled water-10	1

4. CONCLUSION

The present work can be considered as development of water diesel fuels using aqueous metal salts along with additive span and tween. The studies reporting that, an experimental investigation about the influence of water–diesel emulsifying on the main pollutant emissions in single cylinder four stroke cycle diesel engines was controlled. Emulsion A of Sodium Formate, Span 20, Tween 20 achieved significant reductions in the Smoke, HC and NOx emissions from diesel engines without requiring substantial retrofitting of the engines.

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