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ChemTech

International Journal of ChemTech Research

CODEN (USA): IJCRGG ISSN: 0974-4290
Vol.7, No.4, pp 1808-1813, 2014-2015

Reduction of Emissions by Diesel-Water Emulsion

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Abstract: In order to find alternatives to fossil fuels and to solve the increasing pollution problems this study was conducted to investigate the effect of water-diesel emulsion fuel on performance and emission characteristics of a DI diesel engine. Also were studied the possibilities of increasing the water content in diesel and compared it with current issues. Moreover, the performance and emission characteristics of the diesel/water emulsion were compared with those of the petroleum diesel. For comparing the performance characteristics between water-diesel emulsion fuel and diesel fuel, the parameters such as brake thermal efficiency, indicated thermal efficiency, mechanical efficiency, and pressure versus crank angle diagram were considered. To study the emission characteristics, the oxides of nitrogen, smoke, unburned hydrocarbon and carbon monoxide were taken into account.
Keywords: water-diesel emulsion, performance, Emissions, Surfactant.

1. Introduction

Stringent pollution regulations, global warming and depletion of fossil fuels have forced the researchers to find the alternative sources. Among various sources such as adding biodiesel with diesel, EGR technique (for NOx emission) and water addition are the most suitable alternatives. Among the above techniques, water addition gets quick attention in respect of fuel consumption and emission reduction. Water is an easily available source anywhere on the earth. Diesel Consumption is reduced as 10% to 30% of water is added to it.

Pradeep Kumar [1] used two surfactants such as TWEEN20 and SPAN 20 and used 8% of water to make emulsified fuel. The stability of that emulsion was 8 hours. Omar badran [2] also used two surfactants, namely TWEEN80 and SPAN80 with 4% by volume. Ming Huo [3] studied the spray and combustion characteristics of water emulsified fuel. He also demonstrated how Puffing and disruptive droplet combustion were observed near flame liftoff and clearly explained how to identify micro explosion impact on break up.

Micro-explosion in diesel-water emulsion is looked upon as the second atomization, improves fuel combustion and reduces fuel consumption [4]. Diesel-water emulsion also reduces the oxides of nitrogen and particulate matter. A paramount aspect is that diesel-water emulsions can be used without engine modifications [5].Temperature also affects fuel-water emulsion [6]. Emulsion also reduces NOx and particulate matter [1-7]

In this study we used single surfactant of Triton X100 and usage of water was 10% compared with 8% of water used by Pradeep Kumar [1]. The stability of water-diesel emulsion was 4 weeks instead of 8 hours. The amount of surfactant used was 0.2% .HLB of surfactant is 13.5

2. Preparation Of Diesel-Water Mixture

Trials were conducted before deciding on the final emulsified fuel. The composition included 89.8% diesel, 10% water, and 0.2 % surfactant. The surfactant used here was Triton X-100 (iso-octylphenoxypoly ethoxy ethanol) it was to be mixed well and the mixing speed ranges from 10000 rpm to 15000 rpm for a period of 2 minutes to get the stability. This mixture was checked for its stability for more than four weeks. So it could be used in normal conventional vehicles for short time use (up to 25 days).

A. Comparison of fuel properties:

Both diesel fuel and emulsified fuel samples were checked before carrying out experimental work. The table given below shows fuel properties. Adding water to diesel increases the density of the fuel and reduces the calorific value of the fuel.

Table.1 Comparison of properties of fuel

S.No	Property	Diesel	Emulsified Fuel
1.	Density kg/m^3	830	832
2.	Calorific Value, MJ/kg	43.2	40.2

3. Experimental Setup and Testing

A single cylinder water cooled with variable compression ratio engine was used for the experimental investigation. Table.2 shows the engine specification of the test bed.

Table.2 Engine specification.

Make	Kirloskar
Type	Vertical
Number of strokes	4
Number of cylinders	1
Swept volume, cc	661
Clearance volume, cc	37.8
Bore, mm	87.5
Stroke, mm	110
Rated speed, rpm	1500
Rated output, kW	3.5
Compression ratio	17.5

The compression ratio ranged from 12 to 18. An eddy current dynamometer was used as a loading device. Piezo sensor maximum range was 5000 PSI. Crank angle sensor resolution was 1° and maximum speed was 5500 RPM. Exhaust gas temperature was measured with K type thermocouple. AVL five gas analyzer was used for measuring emissions. AVL smoke meter was used for measuring smoke in hatridge smoke units (HSU)

4. Performance And Emission Test Results

A. Pressure vs. Crank Angle Diagram:

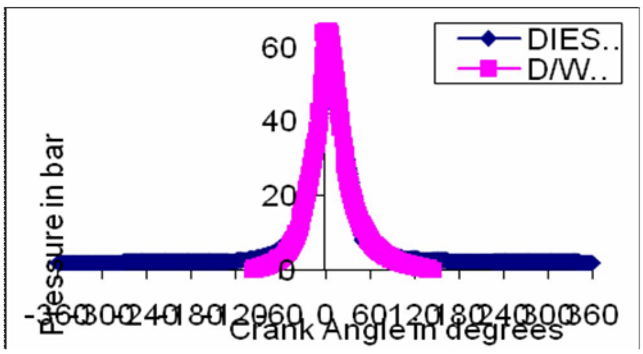

Fig.1 Pressure vs Crank Angle

The pressure versus crank angle diagram shows that the pressure was initially high for diesel. After the injection of emulsified fuel, the pressure gradually increased and reached a maximum value compared with diesel. This was due to the micro explosion that occured in the cylinder.

B. Load Vs Indicated Power

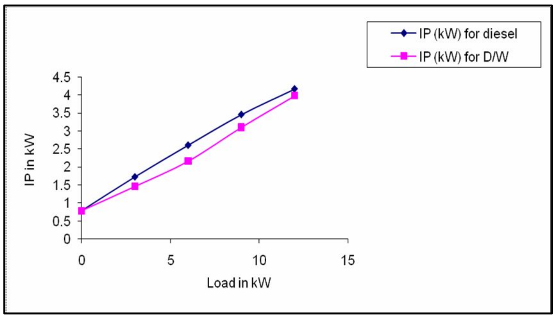

Fig.2 Load Vs Indicated power

From the graph it is clear that the indicated power was the same for both the emulsified fuel and diesel fuel without load condition.As the load increased, the indicated power was reduced to maximum of 17% when compared with diesel fuel. This could be due to the fact that the micro explosion had occurs before the actual burning process started.

C. Load Vs Brake Power

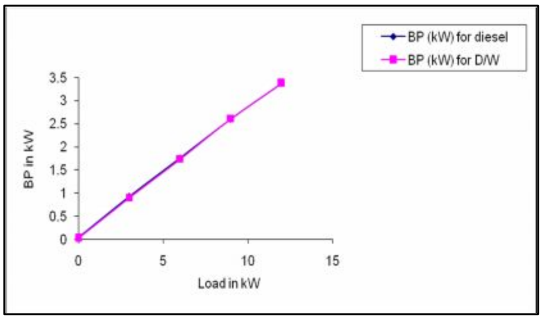

Fig.3 Load Vs Brake Power

The above pictorial representation shows that there was no variation in the brake power when load increased. The energy extracted from emulsified fuel was more than that from petroleum diesel. Because of micro explosion, the oxidation rate of fuel droplets got increased. So the brake power was same as that of diesel fuel.

D. Load Vs Specific Fuel Consumption

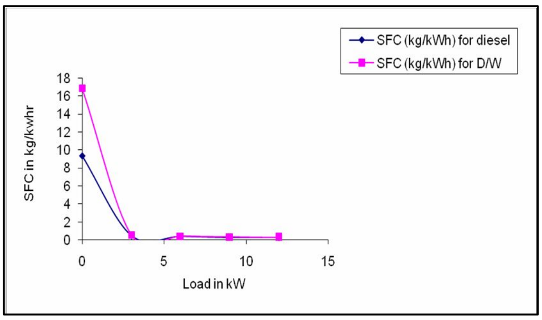

Fig.4 Load Vs SFC

As the load increased, the specific fuel consumption remained the same for both the fuels. Initially it varied by 20%.Pradeep Kumar [1] had reported that the calorific value was less in emulsified fuel due to micro explosion, might be initially it was low so that fuel consumption increased initially at no load conditions.

E. Load Vs Mechanical Efficiency

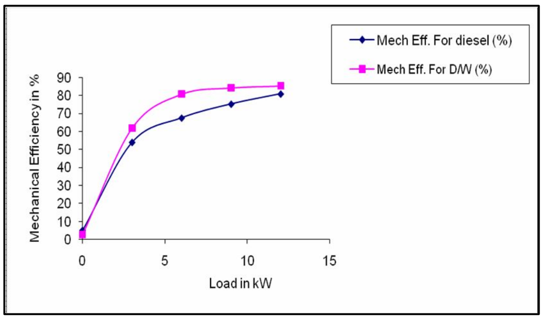

Fig.5 Load Vs Mechanical Efficiency

The mechanical efficiency increased up to 14%. Without load the efficiency was same for both the fuels. But with increasing loads the efficiency also increased to a maximum of 14%.

F. Load Vs NOx

Oxides of nitrogen are formed in engines due to high temperature existing in the engine cylinder. Figure.6 shows that NOx was reduced from a minimum of 10% to a maximum of 17% for all loads. This was due to the water content present in it. Micro droplets of water absorb or suppress the temperature of incylinder mixture. By reducing the adiabatic flame temperature, formation of NOx emission is reduced.

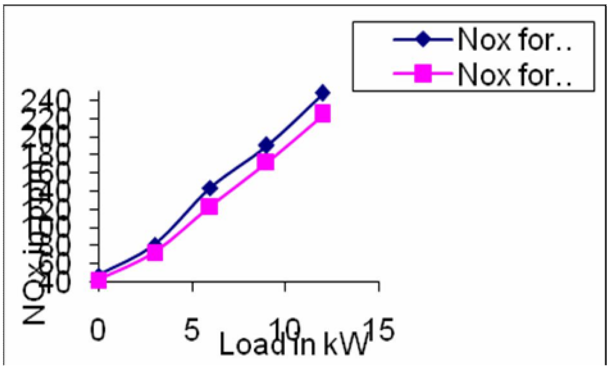

Fig.6 Load Vs NOx

G. Load Vs Carbon Monoxide

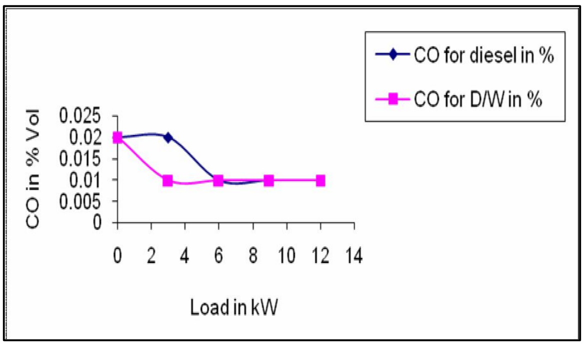

Fig.6 Load Vs Carbon Monoxide Emission

Carbon monoxide is formed due to insufficient oxygen in the incylinder mixture. Fig.7 reveals that at initial load condition the carbon monoxide emission reduced up to 50% compared with diesel fuel. Because of the presesnce of sufficient oxygen with water in it. However, under higher load conditions, the carbon monoxide emission was 0.01% by volume for both fuels.

H) Load Vs Hydro Carbon

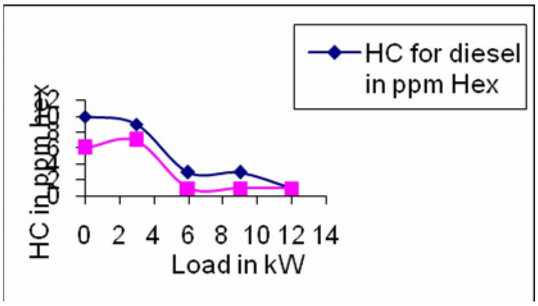

Fig.8 Load Vs Hydrocarbon Emissions

John Heywood [11] has briefly explained how hydrocarbon emissions are formed. Improper mixing, rich mixture, crevices Volume, and over fueling are the factors that contribute to the formation of hydrocarbon emissions. From the above graph, we learn that a reduction of hydrocarbon emission up to 67% was achieved

5. Conclusion

The study was conducted to investigate the effect of water addition to diesel by 10% volume with single surfactant. The composition was 89.8% diesel, 10% water and 0.2% triton X100 Surfactant. This composition was mixed well at the speed ranges from 1000 rpm to 15000rpm. After the mixture was obtained, the performance was studied with a single cylinder diesel engine and all the performance was compared with that of diesel. The findings are:

i. Mechanical Efficiency of emulsified fuel could be increased by 14% when compared with diesel fuel.
ii. Indicated power could be decreased up to 17% for the emulsified fuel. But the brake power remained unchanged.
iii. Specific fuel consumption could be increased at no load condition up to 20%.
iv. Oxides of nitrogen for the emulsified fuel could be reduced from a minimum of 10% to a maximum of 17%
v. Carbon monoxide emission could be reduced up to 50% under part load condition.
vi. Hydrocarbon emission could be reduced up to 67% for the emulsified fuel.

Acknowledgement

The author sincerely thanks Dr.K.Annamalai, Ph.D., Assistant Professor, Department of Automobile Engineering, Anna University (MIT Campus), Chennai, India,for his valuable guidance for this research work.

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