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Study of Emission Characteristics of a CI Engine Fuelled with Water Diesel Emulsion Fuel

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The diesel engine exhaust gas consists of many hazardous components that need to be minimized. Water diesel emulsion (WDE) fuel restricts the emission of such toxic gases and helps to reduce them. Unlike many emission control technologies, WDE fuels give several special advantages including immediate reductions in emissions from both old and new generations of diesel engines without the need for engine hardware modifications. It provides an effective solution for the instantaneous improvement in air quality especially in countries like India, where large population of diesel engines is over 15 years old. The features, which make WDE fuel an effective option for emission control and air quality improvement, are studied. The aim of this research work is to develop stable water-in-diesel emulsion fuel and analyse its emission characteristics in a single cylinder diesel engine with an eddy current dynamometer and five gas analyzer. Three types of emulsion fuels, which includes different percentage of water (0%, 5% and 10%), were produced with suitable surfactant and their properties were analysed. The results shows that 10% water-in-diesel emulsion fuel exhibits better NOx emission level at all loading conditions with a marginal penalty in other emissions.

***Keywords*:** Diesel engine, Emission characteristics, Water-in-diesel emulsion

1. Introduction

The oil prices are continuously increasing with the reduction in supplies of Petroleum; it is inevitable to look towards new solutions for transport purposes. Electric vehicles run by electricity from renewable energy sources could be the sustainable solution in future but till then; it is essential for us to use the current technology & the resources at extreme level. Global warming is another problem which caused largely due to the hazardous emissions from the exhausts of automobiles which includes unburnt hydrocarbons (HC), nitrogen oxides (NOx), oxides of sulphur, oxides of carbon, soot etc. These pollutants can be controlled by many ways. Two of the significant ways are treatment inside cylinder and treatment outside cylinder. Treatment inside the cylinder will be focused on throughout the course of this work. This will be achieved by a process called WDE emulsion [1]. This fuel modification technique is widely trusted by most of the researchers, since the desired engine performance and emissions characteristics can be attained without or with little bit of modifications in the existing diesel engines [2].

The aim of the present study is to investigate the emission characteristics (CO, CO_2, O_2, HC & NO_x) of the diesel engine running with WDE fuel having various concentration of water (0%, 5%, and 10%) and under varying loading conditions at a constant 1500 RPM.

2. Materials & Methods

In this work, diesel purchased from the petrol pump (BPCL, India) was used as the continuous phase & double distilled water was used as the dispersed phase of the emulsion.

Tween 80 & Span 80 was used as the mixed surfactant system (Span 80 + Tween 80 = 2%) to make water-in-diesel emulsion having an HLB value of 9[3]. The surfactants are manufactured by Thomas Baker (Chemicals) Pvt. Ltd.

Table 1. Properties of Fuel samples [4]

Fuel	Density (Kg/M^3)	Calorific Value (Mj/Kg)	Viscosity (cSt)
Diesel	823.42	47.337	3.05
5% WDE	840.67	43.812	3.29
10% WDE	846.80	39.718	3.58

Fig. 1. Photographic view of engine test setup.

Fig. 1 shows the experimental setup of the stirrer used at a constant speed of 2500 RPM for the emulsion preparation. Water was added drop by drop inside the diesel container at a high speed of agitation and stirred constantly for about 20 minute to get the stable water-in-diesel emulsion.

Table 2. Engine Specifications

Parameter	Specification
Make	Kirloskar
Engine Type	Computerized, 4 Stroke, Single Cylinder, Water Cooled
Bore (mm)× Stroke (mm)	87.5×110
Compression Ratio	17.5
Maximum Power Output (Kw/HP)	3.5/5 @ 1500 RPM
Swept Volume (CC)	661
Dynamometer	Eddy Current, Water Cooled with loading unit

Table 3. Gas Analyzer Specifications

Parameters	Measuring %age Range	Resolution	Accuracy Volume
CO	0-10	0.01%	0.06%
CO_2	0-20	0.1%	0.4%
O_2	0-21	0.01%	0.1%
HC	0-20000 PPM	1 PPM	12 PPM
NO	0-5000 PPM	1 PPM	25 PPM

3. Results & Discussion

Here 1Kg of load indicates 0.285Kw of power. Fig. 2 shows the formation of CO emission is higher particularly at lower loading conditions for WDE fuel. This is due to high latent heat of absorption of water particles which leads to low combustion temperature, moisture content and incomplete combustion of WDE fuel. The gap for the amount of CO emission between diesel and 5% WDE shrinks at high load and remains almost similar due to better micro explosion of water particles. The high magnitude of CO formation during the fuel combustion indicates insufficient oxygen supply which is inadequate to completely convert CO to CO_2.

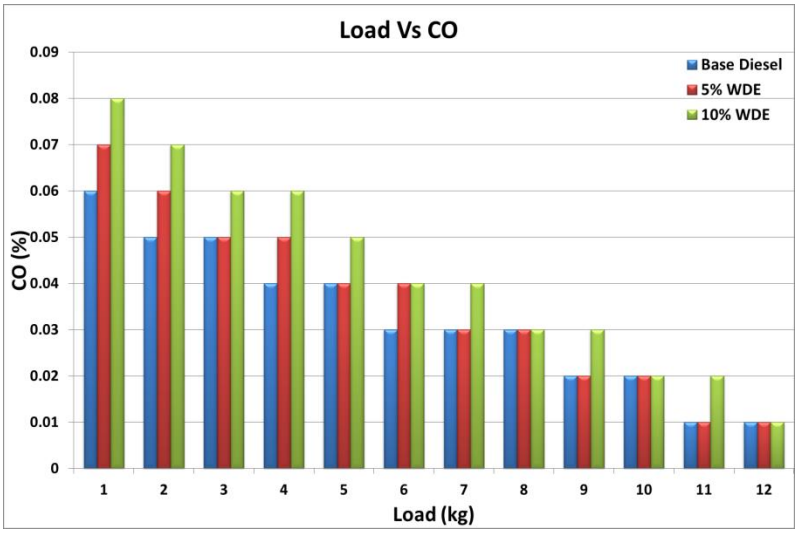

Fig. 2. Load Vs CO

At low to medium loading conditions, WDE shows lower CO_2 emission and it increases at high load conditions as shown in fig. 3. This may be due to high latent heat of absorption of water particles at low loading conditions and better micro explosion at high loading conditions [5]. The WDE promotes high level of CO_2 at high loading conditions as compared to conventional diesel. This may be due to secondary atomization which leads to complete combustion and results in high CO_2 emission. The high emission of CO_2 from the diesel engine indicates the complete conversion of CO to CO_2.

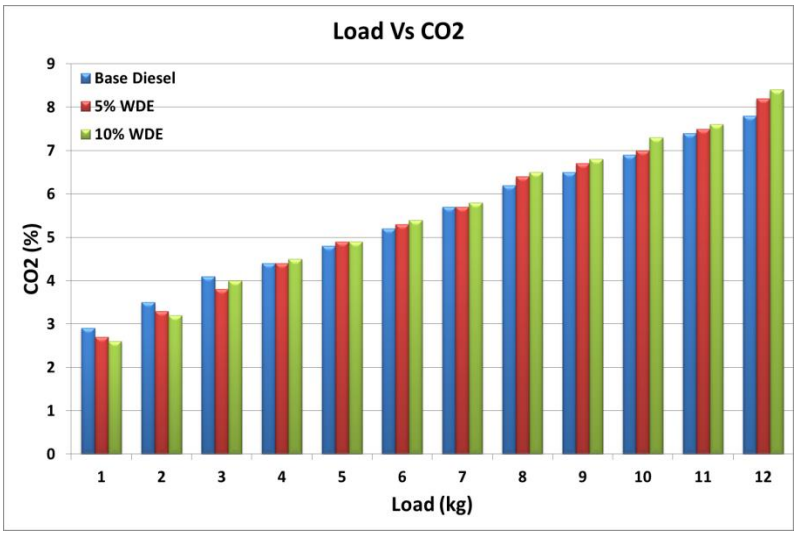

Fig. 3. Load Vs CO_2

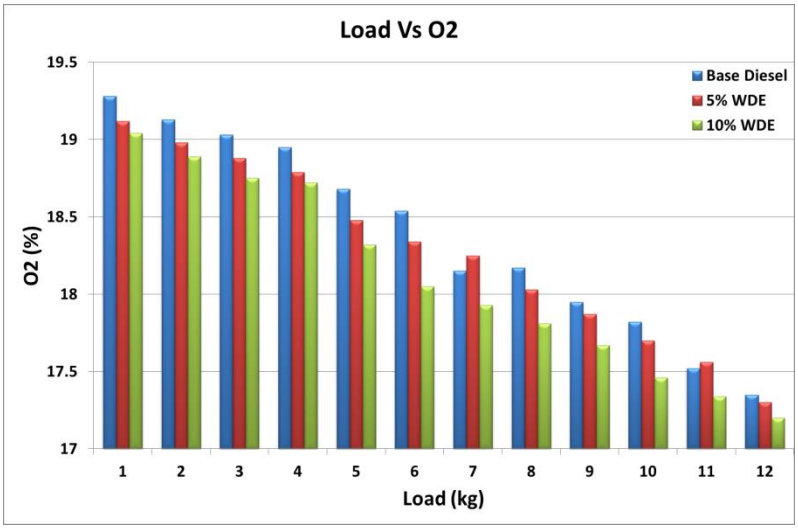

Fig. 4. Load Vs O_2

WDE shows lower percentage of O_2 as compared to conventional diesel for all the loading conditions as shown in fig. 4. This may be due to incomplete combustion of WDE as compared to diesel fuel.

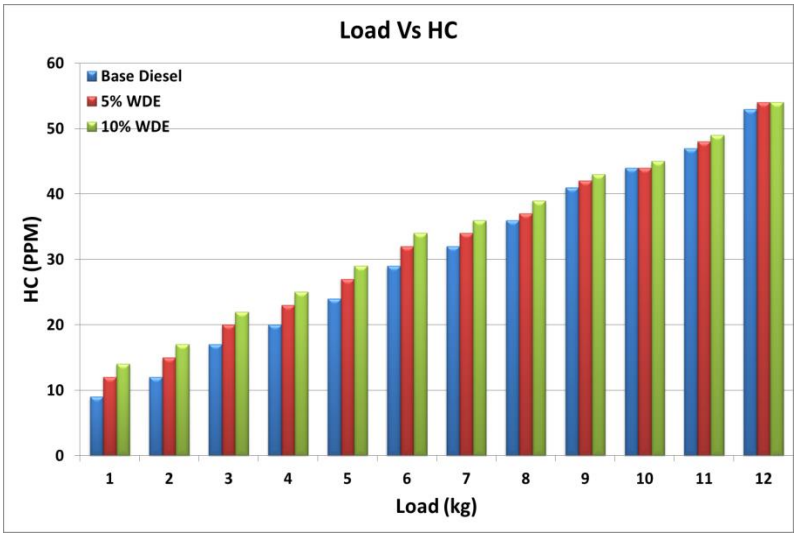

Fig. 5. Load Vs HC

The unburnt hydrocarbon (HC) emission of all fuels is shown in fig. 5 under varying load conditions. At low load conditions, WDE promotes higher magnitude of HC emissions due to low combustion temperature phenomena when compared to conventional diesel. At full load, HC emission was found to decline with increase in water content in the emulsion. Unburnt HC emission of the WDE fuel is slightly higher than pure diesel due to moisture content, poor atomization and incomplete combustion of emulsion.

From the experimental results, it is observed that 10% WDE released least amount of NO_x emission as compared to diesel and 5% WDE. The increase in engine load increases the NO_x emission due to more amount of heat generated. As per as the emission behaviour of WDE is concerned, NO_x emissions are reduced with an increase in water concentration at all the loading conditions as shown in fig. 6.

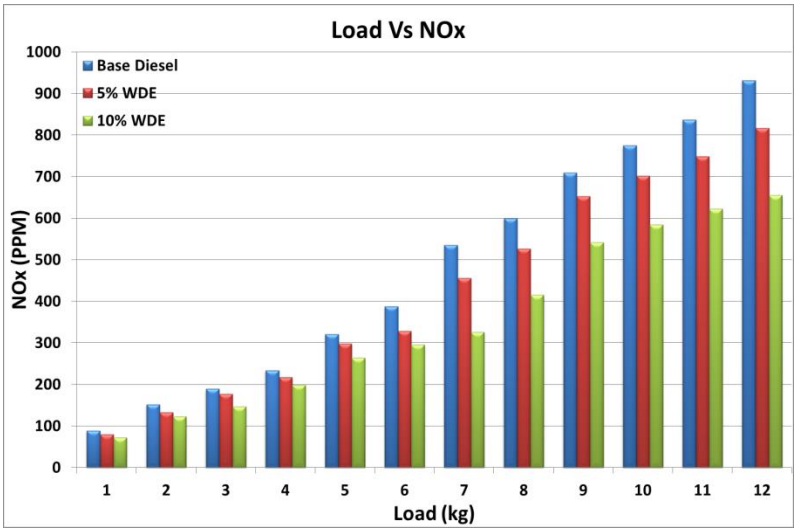

Fig. 6. Load Vs NO_x

4. Conclusion

Following specific conclusions can be drawn from present study;

1. The WDE produced from diesel and its water blends (up to 10%) was directly used as a fuel in diesel engine used for experimental work without any modifications.
2. NO_x emission is found to be reduced with an increase in water percentage in WDE fuel. The water concentration of 10% in WDE fuel exhibits around 30% drop in NO_x emission at full load condition compared to conventional diesel.
3. At low loads, WDE produces more HC and CO emissions due to incomplete combustion and becomes nearly equal to base diesel at high loading conditions.
4. The WDE promotes high level of CO_2particularly at high loading conditions as compared to conventional diesel. This may be due to the secondary atomization which leads to complete combustion of fuel and resulting in high CO_2 emission.

References

[1] A. A. Iyer, I. P. Rane, K. S. Upasani, Y. P. Bhosale, and S. H. Gawande, “Experimental study on the effect of water injection in an internal combustion engine,” Int. Rev. Mech. Eng., vol. 11, no. 6, pp. 379–386, 2017.

[2] T. S. Ravikumar, P. D. Basar, and M. J. Attfield, “Emulsified Diesel - an Immediate and Effective Solution for Diesel Exhaust Emission Reduction,” pp. 259–264, 2001.

[3] H. Patil, A. Gadhave, S. Mane, and J. Waghmare, “Analyzing the Stability of the Water-in-Diesel Fuel Emulsion,” J. Dispers. Sci. Technol., vol. 36, no. 9, pp. 1221–1227, 2015.

[4] A. Sharma, N. Kumar, V. Vibhanshu, and A. Deep, “Emission Studies on a VCR Engine Using Stable Diesel Water Emulsion,” no. February 2017, 2013.

[5] S. Vellaiyan and C. M. A. Partheeban, “Emission analysis of diesel engine fueled with soybean biodiesel and its water blends,” Energy Sources, Part A Recover. Util. Environ. Eff., vol. 40, no. 16, pp. 1956–1965, 2018.

Abbreviations

5% WDE : Water Diesel Emulsion fuel with 5% water content
10% WDE : Water Diesel Emulsion fuel with 10% water content
HLB : Hydrophilic Lipophilic balance

Kg/M^3	:	Kilogram per Cubic Meter
MJ/Kg	:	Mega Joule per Kilogram
CC	:	Cubic Centimetre
cSt	:	Centistokes