Effect of Metal Based Additives on a CI Engine Fuelled With Diesel and Water

[1]Prof. Snehal M. Chaudhari, [2]Prof. Shishir V. Thakare, [3] Kaustubh G. Sontakke3, [4]Mr. Roshan R. Khodke

[1]Assistant Professor, [2]Assistant. Professor, [3]Assistant. Professor, [4]Engineer at Lanco Power ltd.
[1]Dept. of Mechanical. Engineering,
[1]D.M.I.E.T.R.Sawangi (M),Wardha, India

***Abstract*— In this work, the experimental investigation of twin cylinder diesel engine addition of water and metal based additives fuelled with diesel. The test is carried out at constant speed and varying the load condition and investigate the performance and emission characteristics of the engine.**

In the experimentation of CI Engine the Brake specific fuel consumption is increased by 3.33% and 5.43%, NOX emission is reduced by 11.87% and 15% respectively, when addition of 5% and 10% water in diesel. Also with the variation of addition of 3% and 6% fly-ash in 5% and 10% water diesel emulsion, the Brake specific fuel consumption is increased by 6.27%, 7.91%, 5.79% and 8.21%, also Co emission is increases by 22.33%, 12.5%, 36.36% and 22.22% respectively when results comparing with diesel.

***IndexTerms*— Emission, emulsion, CI Engine, diesel metal based additive, water.**

I. 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. [1]

Water acts as a diluents, which lowers the combustion temperature and suppresses NOx formation. The water emulsification decrease overall particulate emissions. Diesel water emulsification may require additional cetane enhancing additives. NOx can roughly be lowered on one- percent reduction for every percent of water added to the fuel, depending on engine design and service profile.[3] The advantage of an emulsion fuel are reduction in the emission of nitrogen oxides and particulate matters, which both are health hazardous and reduction in fuel consumption due to better burning efficiency. An important aspect is that diesel emulsion can be used without engine modification. The combustion efficiency is improved when water is emulsified with diesel. This is a consequence of the micro emulsions, which facilitate atomization of the fuel. [4]

Some metal-based additives are reported to be effective in lowering diesel emissions. They may reduce diesel emissions by two ways. [5] First, the metals either react with water to produce hydroxyl radicals, which enhance soot oxidation, or react directly with carbon atoms in the soot, thereby lowering the oxidation temperature. When these additives are used after combustion in the engine, the metal acts as a nucleus for soot deposition. Usually, the additive is added as a metal-organic compound, and it is emitted in the particulate phase as oxide, on soot particles or forming new nanometre-sized particles by homogeneous nucleation of the additive.

In this project, the addition of water in diesel and this emulsified fuel inject in CI Engine and reduce the emission characteristics of the engine. And also addition of fly-ash in emulsified fuel and improves the performance and reduces the emission characteristics of the engine. Because fly-ash contain various types of metal additives. So fly-ash use as combustion improver and emission reduction additives to increase the efficiency and decrease the NOx emission of the CI Engine.

II. MATERIALS AND METHODS

In experimentation and measurements first prepare the fuel sample and check the properties of fuel sample. This emulsified fuel is fuelled with Twin cylinder Diesel Engine test rig and investigate the performance and emission characteristics of the CI Engine and compare this result to the Diesel Engine fuelled with pure Diesel.

Preparation of emulsion

Components required for making emulsion are: Magnetic stirrer, diesel, distilled water, burette, and pipette. Magnetic stirrer 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.

Selection of Surfactants

An emulsion can be defined as a mixture of two liquids in which one is present in droplets of macroscopic or ultramicroscopic size, distributed throughout the other. Emulsions are made from the constituents spontaneously or by a mechanical way. In spontaneous emulsions, the mixing is easy and spontaneous. (Britannica) But if they don't mix properly then a third chemical called a surfactant is used to bind the molecules of the constituent liquids. Then a magnetic stirrer is used to mix the liquids thoroughly. After mixing them for some time , emulsion is formed.

To help save time in emulsifier selection, ICI introduced in the late 1940's a systematic scheme of centering down on the relatively few emulsifiers suitable for any given application. This is called the HLB System - the letters HLB standing for "Hydrophile-Lipophile Balance.Briefly, the HLB System enables you to assign a number to the ingredient or combination of ingredients you want to emulsify, and then to choose an emulsifier or blend of emulsifiers havingthis same number.At least, this is the principle of the system. Inpractice, unfortunately, the task is never simple.But the HLB System does provide a useful guide -a series of beacons to steer you through channelswhere virtually no other markers exist.

Table 1 HLB values for different types of emulsions.

SURFACTANT	HLB VALUE		HLB VALUE	TYPE OF EMULSION
Sorbitan trioleate (Span 85)	1.8		<10	Lipid soluble (water insoluble)
Sorbitan monooleate, NF, (Span 80)	4.3		>10	Water soluble
Sorbitan monostearate, NF, (Span 60)	4.7		4 to 8	Antifoaming agent
Sorbitan monopalmitate, NF, (Span 40)	6.7		7 to 11	Water in oil emulsifier
Sorbitan monolaurate, NF, (Span 20)	8.6		12 to 16	Oil in water emulsifier
Polysorbate 60, NF, (Tween 60)	14.9		11 to 14	Wetting agent
Polysorbate 80, NF, (Tween 80)	15		12 to 15	Detergents
Polysorbate 40, NF, (Tween 40)	15.6		16 to 20	Solubilize and hydro trope
Polysorbate 20, NF, (Tween 20)	16.7			

So according to HLB value, Sorbitan monooleate, NF, (Span 80) and Polysorbate 80, NF, (Tween 80) these two surfactants are selected and prepare the fuel sample.

III. EXPERIMENTAL SETUP

In experimentation and measurements first prepare the fuel sample and check the properties of fuel sample. This emulsified fuel is fuelled with Twin cylinder Diesel Engine test rig and investigate the performance and emission characteristics of the CI Engine and compare this result to the Diesel Engine fuelled with pure Diesel.

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

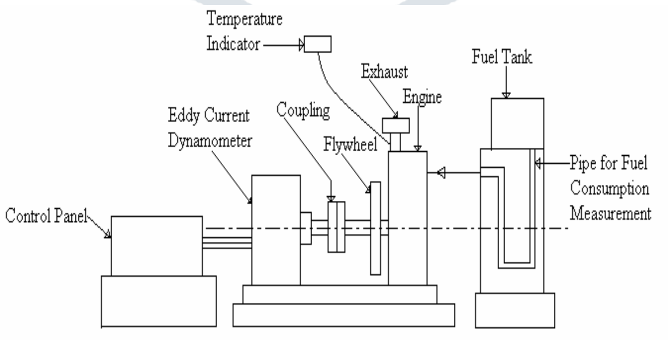


Figure 1: Schematic diagram of Experimental Setup

Diesel engine is tested for performance characteristics. This testing is carried out at various load conditions. The governors will adjust the engine speed nearly equal to load and takes care of it. At no load the engine by hand cranking. The burette is fitted with fuel and time required for 20 ml. Of fuel consumption is recorded with the help of stop watch. Also the speed is recorded with the help of tachometer. The above condition is recorded for various loads. The Brake specific fuel consumption and Brake thermal efficiency is calculated. AVL Gas Analyser is use for measuring the various emission.

Engine specification

Engine	Kirloskar Twin Cylinder Diesel
Type	Vertical four stroke, C.I. Engine
Bore	87.5 mm
Stroke	110 mm
Cubic capacity	1.323 litre
Normal compression ratio	17.5:1
Fuel tank capacity	11 lts.
Governor	Centrifugal Mechanical Type
Speed	1500 rpm
Cooling	Water cooling
Mode of starting	By hand cranking
B.M.E.P. at full load and 1500 rpm	6.33 Kg/Cm^2

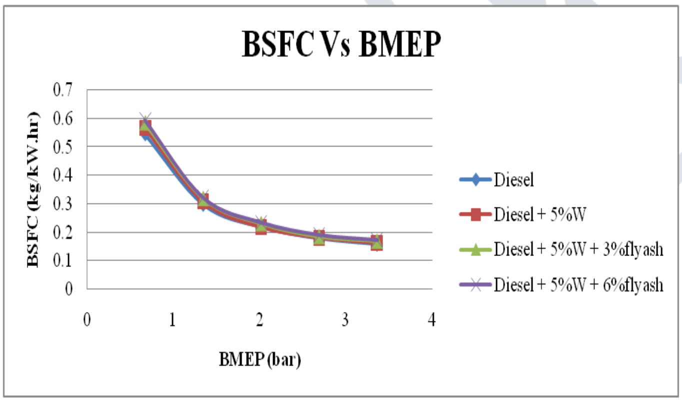
IV. RESULTS AND DISCUSSIONS

This paper describes the performance characteristics and emission characteristics of twin cylinder Diesel Engine test rig using various types of fuel sample. The results were matched against that of diesel and comparison graphs were plotted to see what are the advantages and disadvantages of using the emulsion over diesel.

Brake specific fuel consumption

The Brake specific fuel consumption is increased by 3.33% when addition of 5% water in diesel and also with the variation of addition of 3% and 6% metal additives in 5% water diesel emulsion there is 6.27% and 7.91% Brake specific fuel consumption increases as compare to diesel.

The Brake specific fuel consumption is increased by 5.43% when addition of 10% water in diesel and also with the variation of addition of 3% and 6% metal additives in 10% water diesel emulsion there is 5.79% and 8.21% Brake specific fuel consumption increases as compare to diesel.



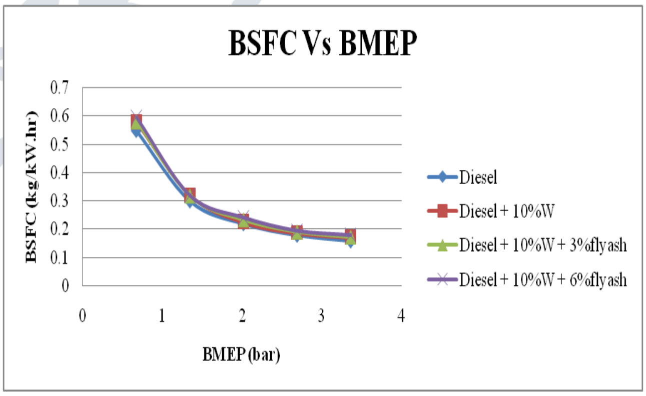
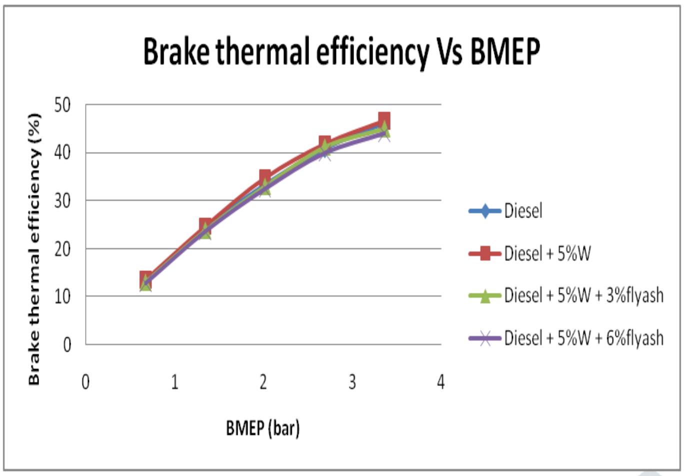


Figure 2: Variation of Brake Specific Fuel Consumption and Brake Mean Effective Pressure

Brake thermal efficiency

The Brake thermal efficiency is increased by 1.55% when addition of 5% water in diesel and also with the variation of addition of 3% and 6% metal additives in 5% water diesel emulsion there is 1.88% and 3.91% Brake thermal efficiency decreases as compare to diesel.

The Brake thermal efficiency is increased by 4.39% when addition of 10% water in diesel and also with the variation of addition of 3% and 6% metal additives in 10% water diesel emulsion there is 3.97% and 1.11% Brake thermal efficiency increases as compare to diesel.



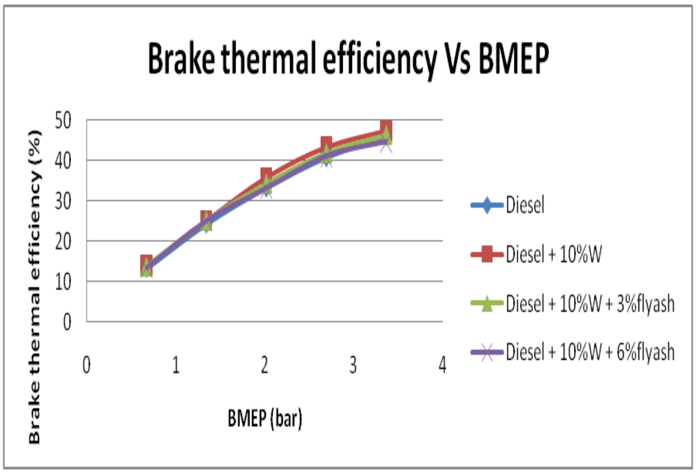
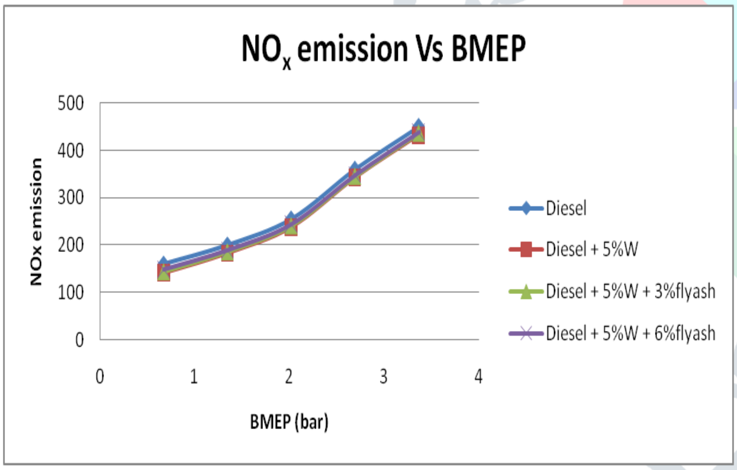


Figure 3: Variation Brake Thermal Efficiency and Brake Mean Effective Pressure

NOX (Oxides of Nitrogen) emission

The NO_X emission is decreased by 11.87% when addition of 5% water in diesel and also with the variation of addition of 3% and 6% metal additives in 5% water diesel emulsion there is 10% and 7.5% NO_X emission decreases as compare to diesel.

The NO_X emission is decreased by 15% when addition of 10% water in diesel and also with the variation of addition of 3% and 6% metal additives in 10% water diesel emulsion there is 13.75% and 11.87% NO_X emission decreases as compare to diesel.



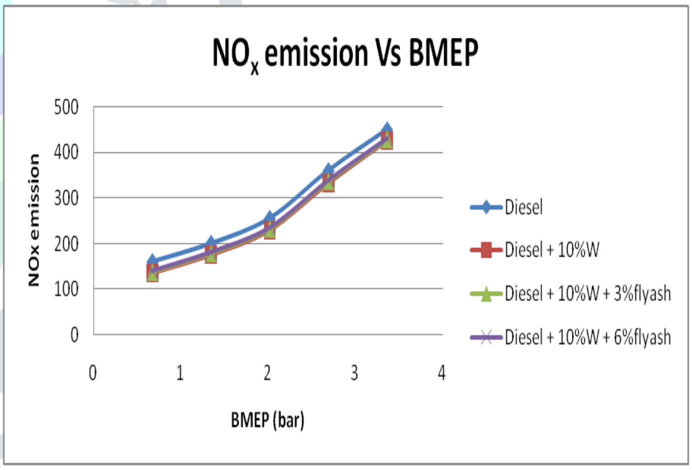


Figure 4: Variation of NOX (Oxides of Nitrogen) emissionand Brake Mean Effective Pressure

Exhaust gases of an engine can have up to 2000 ppm of oxides of nitrogen. Most of this exhaust contains nitrogen oxide (NO) with small amount of dioxide. These all come under NOX, x representing some suitable number. NOX is very undesirable as it has many adverse effects on the environment. With increase in load NOX emission increases for diesel as well as other fuels. It has been observed that using diesel water emulsion as fuel greatly reduces the NOX emissions as compared to diesel. This happens because when water along with diesel enters the combustion cylinder, it is directly vaporized into steam due to presence of high temperature and pressure inside the cylinder. This takes some of the heat from the combustion chamber and brings down the cylinder temperature. As a result the conversion of diatomic hydrogen to more reactive monoatomic nitrogen decreases thereby reducing the chances of formation of NOX.

CO2 (Carbon dioxide) emission

The CO2 emission is decreased by 0.46% when addition of 5% water in diesel and also with the variation of addition of 3% and 6% metal additives in 5% water diesel emulsion there is 0.69% and 1.15% CO2 emission decreases as compare to diesel.

The CO2 emission is decreased by 0.69% when addition of 10% water in diesel and also with the variation of addition of 3% and 6% metal additives in 10% water diesel emulsion there is 0.92% and 1.36% CO2 emission decreases as compare to diesel.

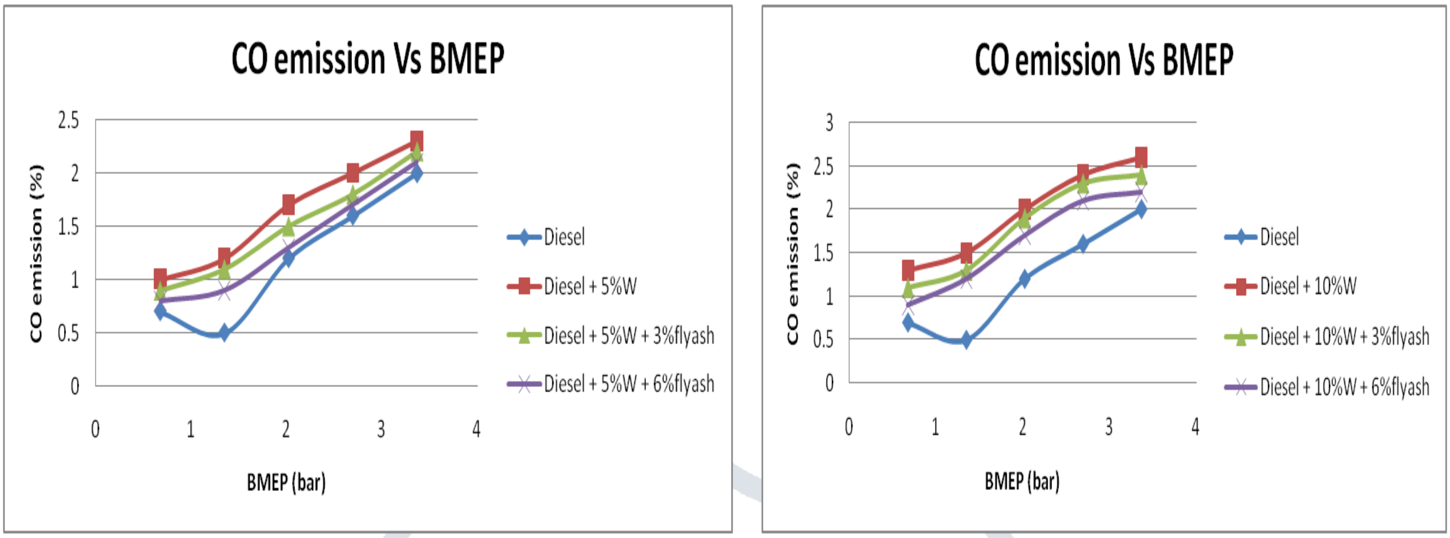


Figure 5: Variation of CO (Carbon Monoxide) emission and Brake Mean Effective Pressure

Carbon dioxide comes as exhaust as a result of complete combustion of carbon particles in the fuel and the combustion of CO inside the cylinder. For diesel it increases linearly with increase in load. For the emulsions too it increases linearly with some variations at some loads. CO2 emission increases when we add water to diesel. With increase in the percentage of water in diesel CO2 emission increases.

Hydrocarbon emission

The Hydrocarbon emission is decreased by 28.57% when addition of 5% water in diesel and also with the variation of addition of 3% and 6% metal additives in 5% water diesel emulsion there is 31.42% and 34.28% Hydrocarbon emission decreases as compare to diesel.
The Hydrocarbon emission is decreased by 40% when addition of 10% water in diesel and also with the variation of addition of 3% and 6% metal additives in 10% water diesel emulsion there is 42.85% and 44.28% Hydrocarbon emission decreases as compare to diesel.

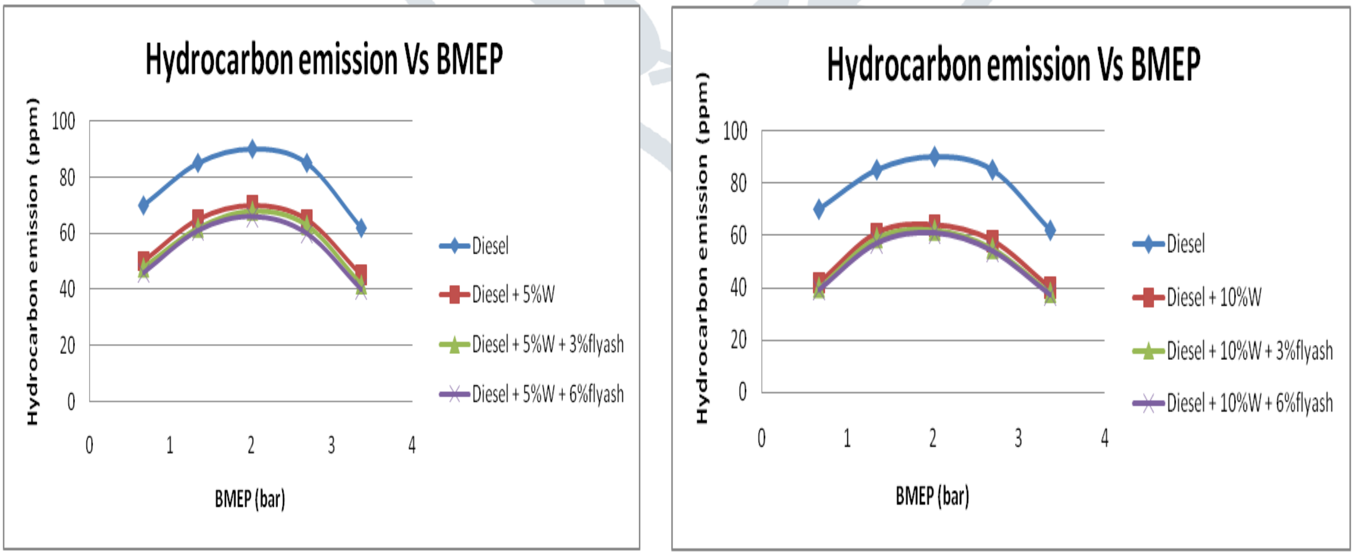


Figure 6: Variation of Hydrocarbon emission and Brake Mean Effective Pressure

Exhaust gases leaving the combustion chamber of a CI engine contains up to 100 ppm of hydrocarbon. These consist of small non equilibrium which is formed when large fuel molecules break up during the combustion reaction. It is often convenient to treat these molecules as if they contained carbon atom. It is seen that HC emissions increases up to a certain load then decreases for diesel. For the emulsions it shows increasing trend as the load increases. Under lower load conditions emission in case of diesel is more than that of emulsions but at higher load conditions the emulsions give more HC (Hydrocarbon) emissions than diesel.

V. CONCLUSION

[1] The brake specific fuel consumption of the engine increases for emulsion than diesel at all brake mean effective pressure. it depends on the concentration of water in the emulsion. The brake specific fuel consumption is also increases with increase the percentage of fly-ash.

[2] It can be observed that brake thermal efficiency for water diesel emulsions are always higher than that of diesel except at very high loads. So emulsions prove out to be better fuels when thermal efficiency is concerned. And addition of fly-ash also increases the thermal efficiency.

[3] With increase in brake mean effective pressure NO_x emission increases for diesel as well as other fuels. It has been observed that using diesel water emulsion as fuel greatly reduces the NO_x emissions as compared to diesel.

[4] The addition of metal additive decreases the HC emission when comparing with diesel. The use of metal additive promotes complete combustion is cause for the hydrocarbon emission reduction.

REFERENCES

[1] M. T. Ghannam and M. Y. E. Selim, "Stability Behavior of Water-in-Diesel Fuel Emulsion", Petroleum Science and Technology. 27:396-411,2009.

[2] Griffin WC: "Calculation of HLB Values of Non-Ionic Surfactants," Journal of the Society of Cosmetic Chemists 5 (1954): 259

[3] Anna Lif a, Krister Holmberg b:" Water-in-diesel emulsions and related systems" journal on advances in colloids and interface science ,27th june 2006.

[4] C. ALAN CANFIELD " effects of diesel water emulsions in diesel engine" thesis submitted in University of Florida, 1999.

[5] Omar Badrana*, Sadeq Emeishb, Mahmoud Abu-Zaidc, Tayseer Abu-Rahmaa, Mohammad Al-Hasana, Mumin Al-Ragheba " Impact of Emulsified Water/Diesel Mixture on Engine Performance and Environment". International journal of thermal and environment engg. (vol 3), 2011.

[6] K. Kannan and M. Udayakumar " NOx and HC emission control using single cylinder engine" VOL. 4, NO. 8, OCTOBER 2009 ISSN 1819-6608 ARPN Journal of Engineering and Applied Sciences.

[7] R.Venkatesh Babu, Dr.S.Sendilvelan, "Reduction of pollutants in CI Engine using emulsion fuels to reduced overall traffic-induced emission" , Global Journal of research Engineering,(2011)ISSN0975-5861.

[8] V. Arul Mozhi Selven, R.B.Anand, M. Udaykumar, "Effect of cerium oxide nanoparticle addition in diesel and diesel-biodiesel-ethanol blends on the performance and emission characteristics of a ci engine",APRN Journal of Engineering and Applies Sciences(2009);ISSN1819-6608.

[9] G.R.Kannan, R. Karvembu, R. Anand, "Effect of metal based additive on performance emission and combustion characteristics of diesel engine fuelled with biodiesel", Applied Energy 88(2011):3694-3703.

[10] Joshi RM, PeggJ, "Flow properties of biodiesel fuel blends at low temperature", Fuel(2007);86:143-51.

[11] Kelso DT, Epperly WR Hart ML, "Effect of platinum fuel additive on the emission and efficiency of diesel engines", SAE Paper 1990:901492.

[12] Yang HH, Lee WJ, Mi HH, Wong CH, Chen CB, "PAH emission influenced by Mn-based additive and turbo charging from a heavy-duty diesel engine", Environ int 1998;24(4):389-403.

[13] V.W.Khond and Swapnil M.Kondawar, "Fly Ash Utilization Technologies and use as Thermal Composite Insulation", Vol. 2, Issue III/April:12, Indian Streams Research Journal.