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Keywords- *Water Emulsions, Additives, Emission control*

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REDUCTION OF POLLUTANTS IN CI ENGINE USING EMULSION FUELS TO REDUCE OVERALL TRAFFIC-INDUCED EMISSIONS

Strictly as per the compliance and regulations of:

Reduction of Pollutants in CI Engine Using Emulsion Fuels To Reduce Overall Traffic-Induced Emissions

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Abstract : Diesel passenger vehicles will require over a 90 percent reduction in NOx and a 75 percent reduction in Particulate Matter to meets the new emission standards over the next few years. Such a large technical challenge will require a systems-based approach combining water emulsion and additives. The emissions improvement achieved by properly designed fuel-water emulsification is universal regardless of engine. The primary benefit of water-fuel emulsions in diesel engines is a notable reduction in NOx emissions. The added water acts as a diluent, 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 of for every percent of water added to the fuel, depending on engine design and service profile. This reduction is achieved by lowering the peak combustion temperature in the engine cylinders. Better fuel atomization and more complete combustion serve to offset any reduced thermal efficiency from the quenching effect of water during the combustion process. The net impact on engine power development and fuel economy is minimal. This paper describes the fundamental approaches, water-diesel emulsion preparation, monitoring emulsion stability, retention period and corrosion testing to utilizing water-fuel emulsions. This paper also describes the analysis of particle size and its effect.

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I. Introduction

The emulsions are engineered to provide reduced carbon particulate, lower capacity and lower nitrogen oxide levels, with increased thermal efficiency. Typically, the larger fuel droplets do not completely burn, leaving unburned carbon to collect on heat transfer surfaces and escape as particulate matter in the exhaust gases. The emulsion is maintained by recirculating the emulsion and adding a ratio of fuel and water to the system to achieve a desired fuel/water ratio in the recirculation loop. The paper relates to an internal combustion engine fueled by relatively heavy petroleum products, such as diesel fuel. The engine incorporates a fuel supply system, which generates a controlled emulsion of fuel oil, and water, which is fed into a cylinder of substantially conventional design. Some of the advantages of water addition to fuel results from a decrease in the combustion temperatures. These temperature reductions result in the suppression of spark-knock and pre-ignition in the engine as well as the reduction of exhaust NOx concentrations and smoke, and lower fuel consumption. In emulsified fuels for use in diesel engines was renewed because of the possibility of reducing the pollutants emitted by automobiles.Diesel engines are gaining much importance nowadays due to its better thermal efficiency and high fuel economy. Reduction of exhaust gas emissions from diesel engines is desirable due to environmental concerns. Especially, NO_x emission has become a serious problem in urban environments where traffic congestion is common and stricter regulations are being enforced in worldwide.At present intense research is being carried in various parts of the world to minimize NO_x emission from diesel engines through improvements in engine design, fuel injection timings, optimization of fuel injection rate, increasing fuel injection system modification is highly difficult. Hence addition of aqueous metal salt solution in the combustion region is most effective way to reduce the oxides of nitrogen compare to other methods.

In this investigation, the effect of several aqueous metal – salt solutions on NO_x lowering in Direct Injection diesel engine exhaust was examined. These salt solutions lower the peak cycle temperature due to its endothermic reaction and thereby lower the NO_x formation. In this experimental investigation on NO_x emission control using variation metal salt solutions such as Sodium Formate, Potassium Carbonate, Calcium Acetate and Potassium Acetate at different brake power have been carried out. I that been experimentally investigated that Sodium Formate metal solution gives maximum reduction in NO_x emission than other metal salt solution – diesel emulsions.

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II. Water-fuel emulsions

A combination of retardation of fuels injection timings, optimization of fuel injection rates, increased in fuel injection pressures with smaller diameter, and exhaust gas recirculation (EGR) is effective and practical for lowering of NO_x, but further lowering seems to be impossible without a deterioration of engine output performance and other exhaust gas emissions.The addition of water in the combustion region is also an effective way to achieve NO_x lowering. NO_x can be significantly reduced with a urea solution injection directly into the cylinder. The results suggest that NO_x could be reduced without deterioration in the thermal efficiency or other exhaust gas emissions if a substance, which suppresses NO_x formation or promotes reduction of NO_x could be put into the burning zone.In this research, the effect of several aqueous metal-salt solution on NO_x in DI diesel engine was examines. The salt solution – diesel emulsion was directly injected into the combustion chamber. The results shows significant lowering in NO_x over a wide operation range could be achieved with alkali metal slat solutions. The degree of NO_x lowering with the solution injection was much larger than with a water injection alone, and the solution also reduced smoke emissions, which was not much affected by water injection.

Essential requirements of aqueous metal salt solution

- It should not cause secondary pollution
- The solution should be non – toxic, less hazardous and should be easy to handle
- It should have a high life time.
- Easy availability in the market
- Cost must be cheap for automotive pollution
- It should reduce more NO_x
- It must have minimum effect on engine performance.

III. Present investigation

With the ever–increasing number of diesel vehicles day by day, all the countries in the world have legislated stringent NO_x emission standards so as to save the environment and the human beings from its evil effects NO_x can be reduced by five different techniques such as charge dilution, in cylinder charge condition, fuel injection system parameter, fuel formation and exhaust gas after treatment. The present investigation aims at NO_x control using aqueous metal salt – diesel emulsion in DI diesel engine. The degree of NO_x lowering with the solution injection was much larger than with a water injection alone, and the solution also reduced smoke emissions, which was not much affected by water injection.

IV. Emulation theory and preparation

The process according to the present invention allows to produce emulsions of liquid fuels and water in which the water is dispersed in the liquid fuel with predetermined dispersion characteristics, particularly as regards the average size of the dispersed water particles. It is believed that this characteristic is decisive in achieving a combustion of high quality in terms of both energy efficiency and polluting emission reduction. In particular, it is believed that high-quality combustion can be achieved with an average size of the water particles dispersed in the liquid fuel of generally less than 1.5 microns, preferably between 0.05 and 1 microns. Moreover, the dispersion characteristics of the water in the liquid fuel directly affect the stability of said emulsion, which is a particularly critical property in the case of low-density liquid fuels (for example Diesel fuels), for which storage in tanks, also for long periods, is usually required. The stability of the resulting emulsions can be evaluated on the basis of any phase separations found after centrifuging a sample of the emulsion at a predetermined speed and for a predetermined time. It is believed that the emulsions of liquid fuels and water have a stability which is sufficient to allow to store them for long periods (more than 1 month) if they show substantially no phase separation after centrifuging at 1000 g (g=acceleration of gravity) for 15 minutes (at room temperature).

An emulsion is a two– phase liquid system consisting of fairly coarse dispersions of one liquid in another in the form of droplets, whose diameter exceeds 0.1 microns. Of the two phase, dispersed phase is present in the form the matrix in which those droplets are suspended. Generally there exist two distinct emulsion types, Oil-in-water type and Water-in-oil type. Water–in–oil type is suited best type of fuel for internal combustion engines rather than oil–in–water type. While using emulsion as fuel the care must be taken so that there mat be on side effects and we should also succeed economically in producing them. The reason behind the use of water– in–oil emulsion (WOE) as engine fuel is mainly due to the micro – explosion phenomenon of droplet of water, which caused large fragmentation of the oil and less change in viscosity with water content.

1) Emulsifying Agents

Emulsifying agents are chemicals, which are added during the process of emulsion preparation. The main aim of adding emulsifying agents in to reduce the interfacial tension between the two liquid phases to form a homogenized stable solution.

2) Types of Emulsifier

- Anionic
- Cationic
- Nonionic

Only nonionic emulsifying agents are suggested for preparation emulsifying fuel for engine application owing to its non – reactive and non – corrosive nature without any source for secondary pollutants formation in engines. In particular, in order to increase the stability of the produced emulsions it is possible to use surfactants or mixtures of surfactants known in the art. Said surfactants are preferably chosen among those which have low environmental impact, do not generate toxic byproducts during combustion and are not corrosive for the metals with which they make contact. Said surfactants can be preferably chosen among: sorbitol esters with fatty acids, optionally containing at least one polyoxyalkylene chain, preferably a polyoxyethylene chain; polyalkylene glycols, preferably polyethylene glycol; polyalkylene glycol esters with fatty acids; or mixtures thereof. The fatty acids can be chosen in particular among stearic acid, lauric acid, oleic acid or palmitic acid. The following are particularly preferred surfactants: sorbitan monoleate, sorbitan sesquioleate, sorbitan monolaurate, polyoxyethylene sorbitan monostearate, polyethyleneglycol hydroxystearate.The use of surfactants is particularly advantageous in the case of emulsions of low-density, low-viscosity liquid fuels, for example Diesel fuels, which typically have a density between 0.83 and 0.87 kg/m^3 and a viscosity between 1 and 3.C^o., which in the absence of surfactants generally form emulsions that show stability problems after prolonged storage in a tank, particularly due to the separation of the lighter petroleum fractions. For Diesel fuels it has been observed that it is particularly advantageous to use a mixture of surfactants comprising 60 to 95% sorbitan monoleate by weight and 5 to 40% polyethyleneglycol hydroxystearate by weight. This mixture, in addition to stabilizing the emulsions that are produced, also acts as a lubricant and antifreeze.

The total amount of surfactants added is selected according to the type of fuel and the effectiveness of said surfactants in stabilizing the emulsion and can generally vary between 0.1 and 8% by weight, preferably between 0.5 and 5% by weight, with respect to the weight of the total emulsion. In the case of liquid fuels having a higher density, the Applicant has instead observed that it is possible to obtain highly stable emulsions even without adding surfactants. This result can be ascribed both to the density and viscosity characteristics of the liquid fuel and to the possible presence, in said fuel, of small amounts of hydrocarbon oxidation products, which can act as surfactants. Additives suitable to reduce sulfur oxide emissions, such as for example sodium or potassium hydroxide, soluble barium or magnesium salts (for example chlorides), or mixtures thereof, can be introduced by means of the water phase. The presence of said products is particularly advantageous if fuels with a high sulfur content are used. The amount of additive to be added is determined according to the stoichiometric ratios required to eliminate a predetermined amount of sulfur, which is in turn calculated as the difference between the amount of sulfur present in the fuel and the maximum allowable amount of sulfur in the exhaust gases. The apparatus according to the present invention allows producing liquid fuel emulsions in which the amount of water can vary over a wide range and is predetermined according to the specific use for which the emulsion is intended. For combustion processes in general, the amount of water can vary between 5 and 45% by weight, preferably between 10 and 35% by weight, with respect to the total weight of the emulsion.

3) Modes of Adding Emulsifier

Having chosen the appropriate emulsifier, there are four recognized ways of incorporation the emulsifier into the system.

- Agents in Oil method
- Agent in Water method
- Nascent soap method.
- Alternative addition method

In the all above four method is generally used to produce Water– in–oil emulsion type. In this method, the emulsifier of dissolved in the oil phase and water is added to it.

4) Fuel Preparation

In order to avoid any side effects in running the engine only nonionic type emulsifying agents were tried to produce emulsion. The stability of the emulsion was tested with different salt solution.

5) Emulsifier Fuel Mixing Procedure

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 (between 80) was first mixed together for 15 minutes using a mechanical mixer as shown in Fig. 1. 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 a macro– emulsion with larger fuel droplets. All emulsion was prepared just before each engine test.

Emulsions having the composition listed in Table 1, were prepared by using the above-described apparatus

Table 1 : Composition (% by weight)

Emulsion	Hydrocarbon	Water	Additive
A	88.0	10.0	2.0
B	86.0	11.5	2.5
C	88.0	10.0	2.0
D	66.0	34.0	--

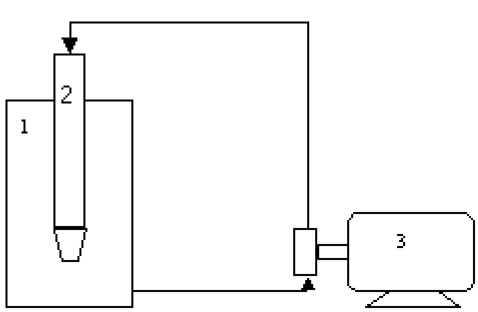
For emulsions A, B and C, the hydrocarbon used was automotive Diesel fuel with a density of 0.836 kg/m^3 while emulsion D was prepared by using fuel oil with a density of 0.95 kg/m^3. Emulsions A, B and C contained, as stabilizing additive, a mixture constituted by 90% sorbitan monoleate by weight and 10% polyethyleneglycol hydroxystearate by weight, while no surfactants were added to emulsion D.

IV. Experimental Procedure

The engine was started on neat fuel and warmed up. The test fuel was selected. If the emulsion were used, the emulsified fuel was introduced into the fuel line and another period of time was allowed for the engine to stabilize. The experimental procedure involves the investigation of the following parameters namely.

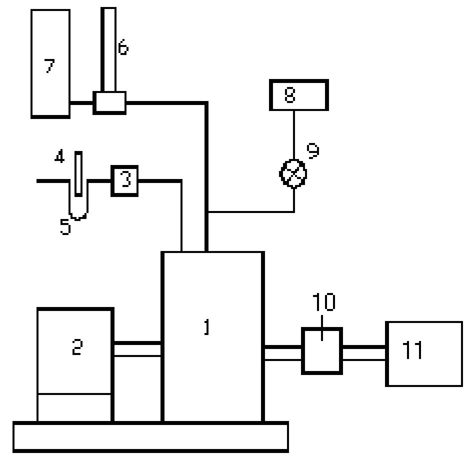
- Brake power
- Brake specific fuel consumption
- Measurement of NOX
- Smoke intensity
- Exhaust gas temperature

Fig. 1: Mechanical Mixer



1. Emulsion Tank 2. Nozzle 3. Motor and Pump

Fig. 2: Experimental Set-up



1.	Engine
2.	D.C Generator
3– 5.	Air Intake
6, 7.	Fuel Reservoir
8, 9.	Emulsion Reservoir
10.	Thermocouple
11.	Nitrogen Oxides Analyzer

1) Measurement of NOx

Oxides of nitrogen were measured with NOX analyzer. The NOX analyzer gives the values NO and NO2 present in the exhaust gas in ppm. Smoke intensity & exhaust gas temperature measurement. Smoke intensities are taken by using HP smoke number and smoke number is evaluated using Bosch Smoke Meter in Bosch Smoke Units (BSU). Exhaust gas temperature is measured by using Iron – constant thermocouple with dial indicating unit.

2) Particulate Emission Measurement

Particulate mass calculation is measured by weighing the filters on an electronic microbalance before and after collection. The filter paper is exposed to the exhaust for a period of 5 minutes and hence particulate emission is measured in Grams Hr. similar procedure was adopted for all the other engine loads. The same sequence was repeated for the emulsified fuel containing salts.

V. Conclusion

It has been found that combusting water and diesel fuel emulsion in a diesel engine as a way to reduce nitrogen oxide emissions but it can lead to mechanical problems. These problems are usually caused by the fact that the components of the engine are designed to operate within the lubricity characteristics of diesel fuel. Since a water and diesel fuel emulsion has lubricity far less than that of diesel fuel, a great deal of damage to the diesel engine components can be caused by combusting a water and fuel oil emulsion in the engine. Although this problem is apparent in virtually all diesel engines, it is especially significant for engines having aluminum parts, which are more sensitive to damage in this way than steel, especially stainless steel, parts. What is desired, therefore, is a method and composition which can achieve significant reductions in the NOx emissions from diesel engines without requiring substantial retrofitting of the engines, nor an increase in emission of other pollutants. The method and composition selected should be capable of being instituted on a commercial level without significant infrastructure changes.

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