STUDY ON REDUCTION OF NO_X IN DIESEL ENGINE USING DIESEL-WATER EMULSION METHOD

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Abstract - *Using an emulsion of diesel in water as a fuel has been a recent study in this field. Diesel/Water emulsified formulations are reported to reduce the emissions of NOx, SOx, CO and particulate matter (PM) without compensating the engine's performance. In this study, a new kind of emulsion is prepared by mixed surfactant method, major concern being the long term stability of the same. The emulsion contains 89% of diesel, 10% of distilled water and 1% of surfactants (0.5%of span 20 and 0.5% of tween 20). The addition of water leads to the complete combustion of engine, more the water addition more the complete combustion takes place.*

Key Words: **Diesel Engine, Emissions, Micro-emulsion, Span 20, Tween 20**

1. INTRODUCTION

Diesel engines exhausting gaseous emission and particulate matter have long been regarded as one of the major air pollution sources, particularly in metropolitan areas, and have been a source of serious public concern for a long time. There have been numerous researches in the field of reduction of these pollutants since diesel engines came to major use. Major emissions from a diesel engine are NO_x, SO_x, CO and particulate matter (PM), among these pollutants CO and SO_x and some quantity of particulate matters are reduced by some after treatment methods, outside the engine, in the catalytic converter etc. unlike these NO_x can't be oxidized to get some clean product.

The use of water in diesel engine has various benefits [1]. It is observed that use of diesel-water emulsion has an influence on reduction of peak temperature which then reduces emission (NO_x). The technique with introducing water into the combustion chamber was proposed by Prof. B. Hopkinson in 1913, to make the better cooling of gas engine and to increase the engine output [2]. Furthermore, it was developed to improve the thermal efficiency and reduce exhaust emission. Four major approaches for introducing water into the combustion zone have been reported. (i) Hybrid injection, using a single injector or an as stratified diesel-water-diesel fuel injection by means of a specially modified nozzle. (ii)Direct injection into the engine through separate injectors (DWSI). (iii) Fumigating the water into the engine intake air (FWIA). (iv) Diesel-Water emulsions (DWE). All the methods are proposed to introduce water into the appropriate, because they require no engine retrofitting [4]. Although all these methods determined a reduction of NO_x emission, it has been concluded that the use of diesel-water emulsion was the most effective technique for the reduction of diesel particulates for direct injection diesel engine [8]. It has also been shown that adding water may help to improve atomization and mixing, when it is attributed to emulsion droplet micro-emulsions.

Since diesel-water emulsion has a potential in reducing NO_x and PM emissions of diesel engines, this paper presents a literature review on emulsion significant aspects that determined its use in diesel engine and its influence on diesel engine performances.

1.1 Diesel-Water emulsion

An emulsion consists of two incomplete immiscible liquids (usually oil and water), with one of the liquids dispersed as small spherical droplets in the other [9,10]. According to [11], 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. In an emulsion, the droplets of one phase (the dispersed or internal phase) are encapsulated within sheets if another phase (continuous or external phase) [12]. The essential characteristic of an emulsion is its droplets size distribution [10]. Generally, there exist two distinct diesel-water emulsion types, water –in-oil and oil in water type [11]. Water in oil type is the best suited type of fuel for diesel engines rather than oil-in-water type due to the micro-explosion phenomenon of droplets of water, which causes large fragmentation of the oil and less change on viscous with water content. A surfactant can reduce the oil and water surface tension, active their surfaces, and maximize their superficial contact areas to make oil-in-water or water -in-oil two phase emulsion [14]. Surfactants or surface-active agents are amphipathic substances with lyophobic and lyophilic groups making them capable of adsorbing at the interfaces between liquids, solids and gases [12]. A surfactant is also called an emulsification agent because it can stabilize emulsions when it exists along the interface between water and oil [14]. In diesel-water emulsion, the surfactants suspended the water droplets in the fuel, thus the water does not come into the direct contact with engine surfaces [4]. The additives are included to maintain the emulsion. Enhance the lubricity, inhibit corrosion and protect against freezing [15].

Oil-water emulsion can be classified on the basis of relative spatial distribution of the oil and aqueous phase [9]. A system that consist of water droplets dispersed in an oil phase is called a water-in-oil or W/O emulsion and a system that consist of oil droplets dispersed in an aqueous phase is called an oil-in-water or W/O emulsion [9, 11, 16, 17]. Multiple emulsions are composed of three phase: an inner and an outer phase separated by a dispersed phase [16]. Three phase emulsion or double phase emulsion is denoted as: O/W/O (oil-in-water-oil) and W/O/W (water-in-oil-water). Diesel-water emulsion can be classified according to the size of droplets in the emulsion. The size of the drops in an emulsion are in the range of 1-10 µm [20], while in a micro-emulsion are much smaller, e.g. 5-20 nm [20] or less than 0.2µm [6]. 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 droplets, commonly oil droplets in water, exhibiting sizes lower than 300nm [21].

2. RESULT AND DISCUSSION

2.1 Brake Specific Fuel Consumptions (BSFC)

Brake specific fuel consumption of an engine is defined as the amount of fuel used in kg per brake power per second. This is an important performance parameter as it determines the mileage of the vehicle. In practical purposes this very important aspect a consumer looks for, as it determines whether the product is value for money or not. It is seen from the graph (Chart 2.1) that the bsfc of the engine increases when emulsion is used, but it also depends on the concentration water in the emulsion. It decreases up to a certain limit and then again increases. The bsfc is best obtained for the emulsion with 10% of water. Use of water increases the combustion efficiency of the engine by keeping the temperature in the working range. After a certain point when volume of water increases more, it inhibits the combustion.

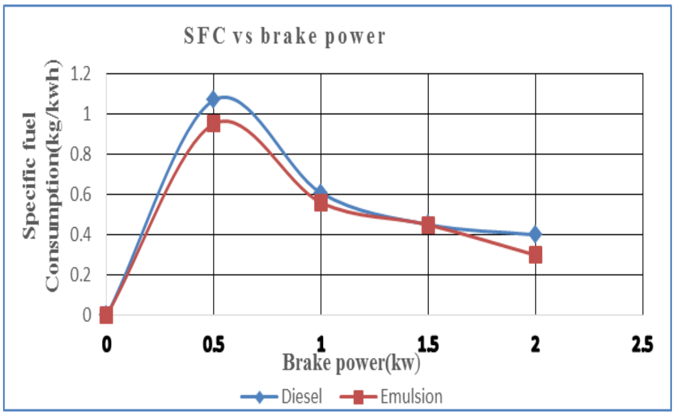

Chart 2.1 Specific Fuel Consumption Vs. Brake Power

2.2 Brake Thermal Efficiency (ɳbte)

Brake thermal efficiency of a vehicle is a very important performance parameter. It increases with increase in load. It can be seen that it increases linearly for diesel. Whereas for the emulsions it increases initially till a load and then decreases. But it can be observed that BTE for emulsions are always higher than that of diesel except at very high loads. So emulsions proveout to be better fuels when BTE is concerned. Chart 2.2 shows graphical representation below.

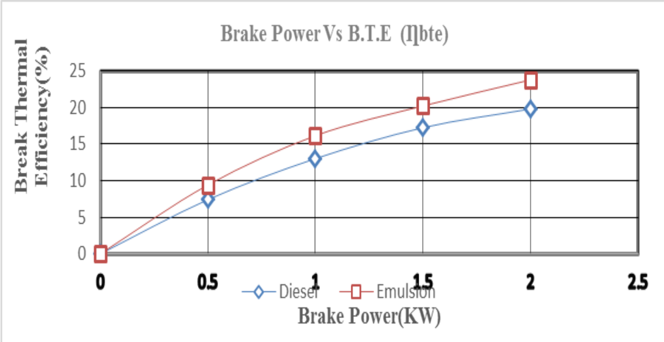

Chart 2.2 Brake thermal efficiency vs Brake power

2.3 Emission characteristics.

2.3.1 Nitrogen dioxide (NOx):

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 effect on the environment. With increase in load NOx emission increases for diesel as well as other fuels. It has been observed (Chart 2.3) 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.

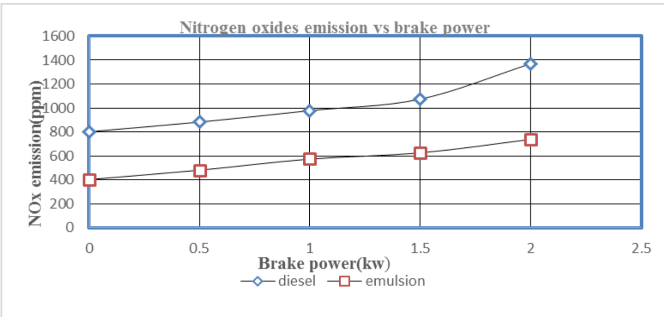

Chart 2.3 Graph of NOx Emission against Brake Power

2.3.2 Carbon monoxide:

Carbon monoxide is emitted as a result of incomplete combustion of carbon and oxygen under high temperature inside the cylinder. With increase in load CO emission increases for all the fuels used. It has been observed (Chart 2.4) that emission of CO increases with increase in volume of water in the emulsion. This happens because with increase in water the temperature inside the cylinder decreases slowing down the combustion of carbon, as a result of which incomplete combustion occurs.

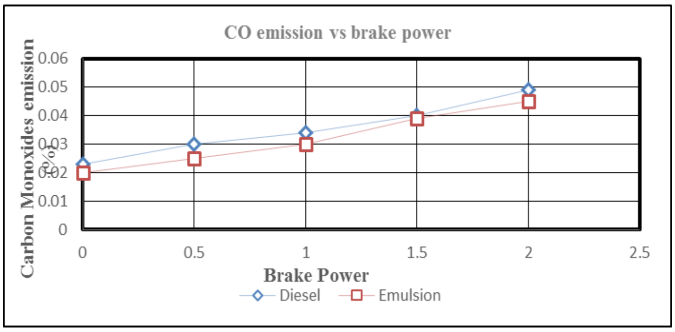

Chart 2.4 Graph Showing CO Emissions against BP

4.3 Carbon dioxide:

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 as shown in Chart 2.5 below.

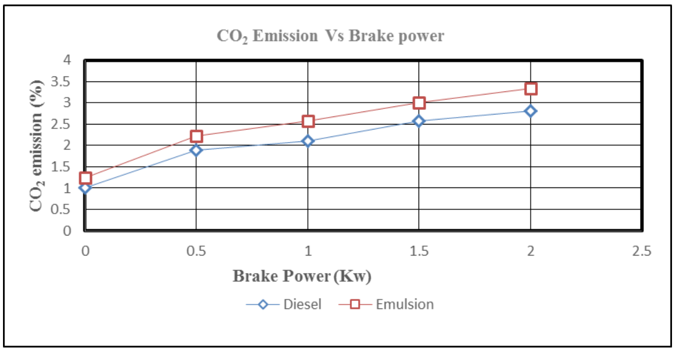

Chart 2.5 Graph Showing CO_2 Vs B.P

4.5 Hydrocarbon (HC):

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 emissions than diesel which is shown in graph below in Chart 2.6

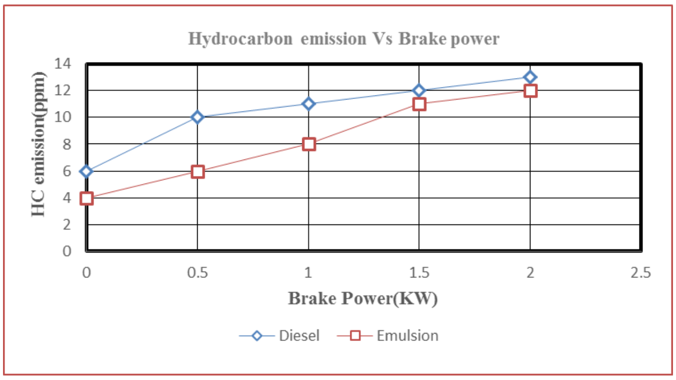

Chart 2.6 Graph of HC Vs B.P

3. CONCLUSION

The specific fuel consumption was observed to decrease with increase in the percentage of water in diesel. Results show that specific fuel consumption is decreased by 2% to 3% when concentration of water is increased from 5 % to 10%, but further increase may increase the specific fuel consumption. However, at higher loads the fuel consumption is more for emulsions than diesel. The brake thermal efficiency of the engine increases with increase in water content emulsion under low load condition. But it decreases at higher loads. The NO_x emission is brought down by 30% - 50 % by use of diesel water emulsion. This trend goes on increasing with increase in amount of water in the emulsion. At lower loads the hydrocarbon emissions are lesser for emulsion as compared to diesel, however when the load increases HC emissions are higher for emulsions. Carbon monoxide and carbon dioxide emissions increase with increase in water percentage in the fuel. This is due to the fact that most of the hydrocarbons are burnt at lower loads. For optimal results, use of diesel water emulsion with 10% water content will give the best results in terms of performance and emission.

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