International Journal of Latest Engineering Research and Applications (IJLERA) ISSN: 2455-7137

Volume – 02, Issue – 09, September – 2017, PP – 37-41

Research Study of Water- Diesel Emulsion as Alternative Fuel in Diesel Engine – An Overview

K R Patel[1], Vijay Dhiman[2]

1, Mechanical Engineering Department ,Vishwakarma Government Engineering College Chandkheda, Ahmedabad

2, Mechanical Engineering Department Dr. S & S S Gandhy Government Engineering College, Surat.

Abstract: The need for more efficient fuel and a less polluted environment are the prominent research areas that are currently being investigated by many researchers worldwide. Water-in-diesel emulsion fuel (W/D) is one of the promising alternative fuel. It can improve the combustion efficiency of a diesel engine and reduce harmful exhaust gases, especially nitrogen oxides (NO_x) and particulate matter (PM). There have been many W/D emulsion fuel studies, especially regarding performance, emissions and micro-explosion phenomena. This review paper gathers and discusses the recent advances in emulsion fuel studies in respect of the impact of W/D emulsion fuel on the performance and emission of diesel engines. It is agreed by most of the studies that W/D does result in an improvement in engine performance measurements when the total amount of diesel fuel in the emulsion is compared with that of the neat diesel fuel. NO_x and PM exhaust gas emissions are greatly reduced by using the W/D emulsion fuel. Unburnt hydrocarbon (UHC) and carbon monoxide (CO) exhaust emissions are found to be increased by using the W/D emulsion fuel. The factors that affect these measurements consist of the type of diesel engine and engine operating conditions, droplet size of the emulsion, water-content in the emulsion, type and percentage of surfactant, ambient temperature, ambient pressure.

Keywords: Water- diesel emulsion, diesel engine, emission, performance

I. Introduction

There is a growing interest in the use of diesel emulsions as alternate fuel as environmental aspect. As is discussed in some detail below water has a significant effect on several emission constituents: exhaust gases such as nitrogen oxides(NO_x) and carbon monoxide (CO), as well as black smoke and particulate matter[1]. Operational advantages of diesel engines are clear, the general public has considerable concerns regarding the pollution caused by diesel engines in the form of obnoxious odor, gas pollutants and particulate matter to atmosphere. Diesel particulate emissions are small, often less than 2.5 lm in size, and consist of a complex mixture of engine's oils, sulfates and inorganic materials. These particles have been identified as toxic air contaminants and declared by health experts as ''likely human carcinogen'' contributing to a variety of lung related illnesses including asthma, emphysema and bronchitis [5]. Due to the severe environmental issues that the world is facing recently, new emission regulations are constantly being introduced in order to mitigate this problem. In addition to environmental disputes, the issue of critical fossil fuel reserves is another concern. Some studies estimate that the worldwide fossil fuel reserves will last less than four decades [3]. Accordingly, these two serious issues have generated research interest worldwide in order to curb and find a solution to these problems. Currently, the more efficient utilization of energy and less polluting emissions are the prominent research areas that are progressively being studied [4]. The W/O emulsion fuel is the most suitable and widely used as the alternative fuel for fueling diesel engines by researchers and experts. The water-in-diesel emulsion fuel type is preferable to be the alternative fuel compared to the water-in-gasoline emulsion fuel. This is due to the difference in boiling point between water and diesel fuel being much higher than the one between water and gasoline, which is particularly suitable for the concept [4].

II. Water in Diesel Emulsion

Considering the enormous volume of diesel fuel that is being consumed today, a replacement of just a fraction of regular diesel by water-in-diesel emulsion. The stability requirements on such emulsions are obvious: they need to stay stable for a specific time and over a wide temperature span. The surfactants used must burn readily without soot formation and should not contain sulphur and nitrogen. Thus, they should contain only carbon, hydrogen and oxygen and they should preferably not have aromatic rings in their structure. Non ionic surfactants based on aliphatic hydrocarbon tails, such as alcohol ethoxylates, fatty acid ethoxylates and sugar esters of fatty acids, are typical emulsifiers [1]. The stability of the emulsion produced is very important in order to ensure this alternative fuel can run accordingly in the engine. If the emulsion is destabilized during the engine

running time, the probability of the engine failure to operate is high. Plus, it may damage the parts inside the engine. Normally, water-in-diesel emulsion fuel can maintain its stability for up to 3 months [7] but it will depend on various factors, such as the type and percentage of surfactant, the temperature, viscosity, specific gravity and water content [4].

The current emulsification technique application to internal combustion engines or industrial furnaces is limited to a two-phase water-in-oil emulsion, (briefly termed W/O emulsion). No literature on the use of three-phase emulsions as an alternative fuel for combustion equipment such as diesel engines has been found [4][17]. The three-phase emulsions may be conveniently divided into two types, i.e. oil-in-water-in-oil (O/W/O) and water-in-oil-in-water (W/O/W) emulsions. The former type, O/W/O emulsions are especially applicable for fuel purposes. A schematic diagram of the W/O and O/W/O emulsion structures is shown in Fig. 1. An inner and outer phases separated by a dispersed phase is widely used in cosmetic, pharmaceutical, physical, chemical and engineering applications.

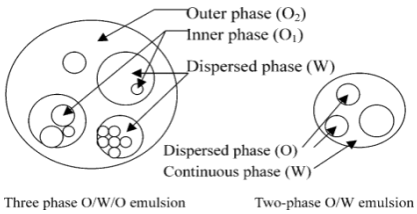

Fig. 1. Physical structures of two-phase and three-phase emulsion[2].

Three-phase emulsions, such as the O/W/O type, have been applied in cosmetics, food or pharmaceutical manufacturing. However, those emulsions have not been used as fuel for internal combustion engines or boilers. O/W/O three-phase emulsions were used as alternative fuel for a diesel engine in the experimental study [3].

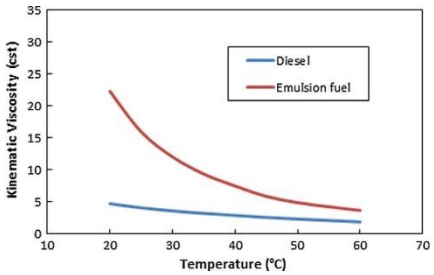

Fig.2. Kinematic viscosity of the fuels under different operating temperature[8].

There are three commonly used techniques for preparing three-phase emulsions; (1) phase inversion, (2) mechanical agitation, and (3) two-stage emulsification. The two-stage emulsification is the most frequently used method. A hydrophilic surfactant is added into the water in the first O/W/O emulsion preparation stage. Oil is then added into the water/surfactant mixture. A homogenizing machine was used to stir the mixture in order to form a two-phase oil-in-water emulsion (denoted as O/W) type. The O/W emulsion is then added into an oil and lipophilic surfactant mixture, which is being stirred by a homogenizing machine so that an O/W/O three-phase emulsion is produced [3].

The viscosity of the fuel is one of the major properties affecting fuel atomization and evaporation, subsequently on the combustion, so a knowledge of the viscosity of the fuel is important. Fig. 2 shows the viscosity of the emulsion fuel and pure diesel under different operating temperatures. It can be seen that the viscosity of the emulsion fuel is higher than that of pure diesel. At the same time, the viscosity of the emulsion fuel drops very fast with the increase of temperature[8].

III. Engine Performance

The engine performance analysis has included the following features: torque, brake power, brake specific fuel consumption, and brake thermal efficiency [8,9,10].

Different operational conditions were studied. And the characteristic behavior of the engine performance under various emulsions were recorded and analyzed. The torque with a function of engine speed is plotted in Fig. 3. It can be seen that at low revolution per minute (rpm), torque increases as engine speed increase until it reaches a maximum value around 1400 rpm. Afterwards, as engine speed increases above 1400 rpm, the torque starts to decrease. This is due to engine being unable to ingest a full charge of air at high speeds.

Also Fig. 3 illustrates that as the percentage of water increases in the emulsion sample, the torque produced increases. This may be attributed to the additional force on top of the piston provided by the pressure exerted by the vapour from the emulsified liquid. When the charge is fired in the cylinder, the water would turn to high pressure vapour. In addition, due to the higher viscosity of the emulsified fuel than that of the base fuel (pure diesel), and the presence of water promote a finer cloud which promotes atomization of the emulsified mixture during injection. This improves engine efficiency significantly[10].

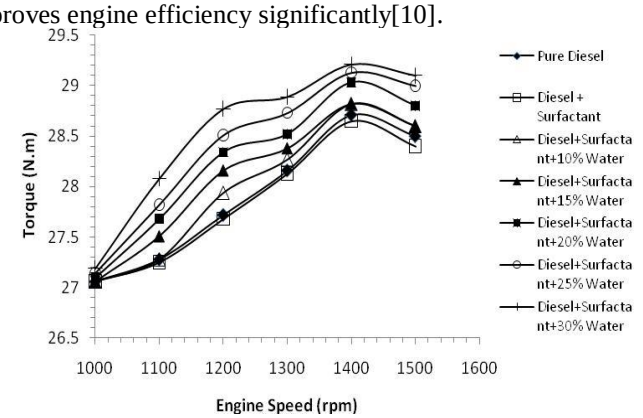

Fig. 3 Engine torque versus engine speed using water diesel emulsion [10]

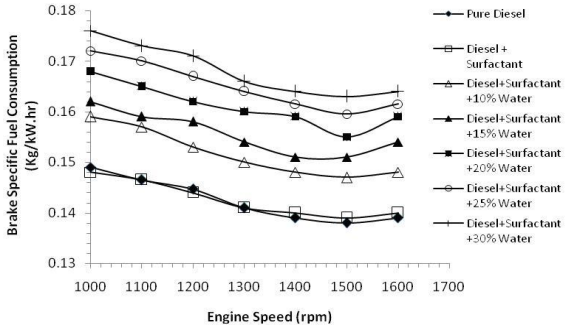

Fig.4 Brake specific fuel consumption versus engine speed [10]

Fig. 4 shows the variation of brake specific fuel consumption (BSFC) with engine speed considering the emulsion (diesel+water) as total fuel. It shows that BSFC decreases as engine speed increases (at low speed), and then it would reach a minimum and then increases at higher speeds. It is that as the water percentage in the emulsion increases, the BSFC increases, this is because as the percentage of water in the emulsion increases, a larger amount of diesel is displaced by an equal amount of water. This means that less diesel fuel is actually contained within each volume of the emulsion. As the percentage of water in the emulsion increases, BSFC of diesel decreases (i.e. diesel calorific value decrease). The minimum value occurs at a water percentage 30% by volume. The reduction in BSFC with water emulsified diesel may be attributed to formation of a finer spray due to rapid evaporation in the water, longer ignition delay results in more fuel burning in premixed combustion and suppression of thermal dissociation due to lower cylinder average temperature[10].

The Emulsified fuels have clear effect on combustion process. This is evident where the increase in water concentration in the emulsion produces a significant increase in the ignition delay[9].

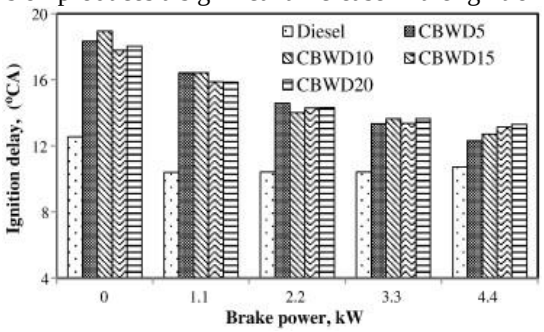

Fig -5. Variation of Ignition delay with brake power[9]

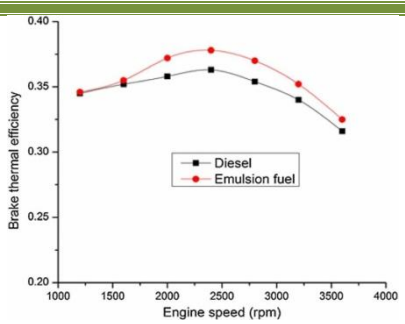

Fig. 6. Brake thermal efficiency of the engine at full load[7].

Fig. 6, we can see that the brake thermal efficiency of the emulsion fuel is higher than that of pure diesel especially at mid and high speed conditions. This is the effect of micro-explosion of the water droplets contained in the emulsion fuel, which helps to break the big oil droplets into many smaller oil droplets, accelerating fuel evaporation and the mixing with air, thereby resulting in a faster combustion process and a higher brake thermal efficiency. Study indicated that the emulsion fuel with high water concentration could improve the efficiency of the engine at high load conditions, however, there was a drop in efficiency when the engine was operating at low load conditions [7].

IV. Exhaust Emission

Most studies reported that the formation of NO_x is greatly reduced when using the W/D emulsion fuel [4],[9],[11],[15]-[16]. Some studies found that the formation of NO_x can be reduced by up to 50% [12].Some researcher stated that 20% of water in the emulsion reduces the formation of NO_x by 20% [13]. Others reported that NO_x is decreased by 30% by using 25% of water in emulsion fuel [14]. In addition, one study revealed that the reduction of NO_x has a strong relation with the increase in the water percentage [15]. Many researchers agree that the reduction of NO_x when using emulsion fuel is because of the lower peak temperature of the flame during the combustion [11],[15]-[16]. The reduction of the temperature is due to the high latent heat from the evaporation of water in the emulsion that absorbs the heat during the combustion [4].

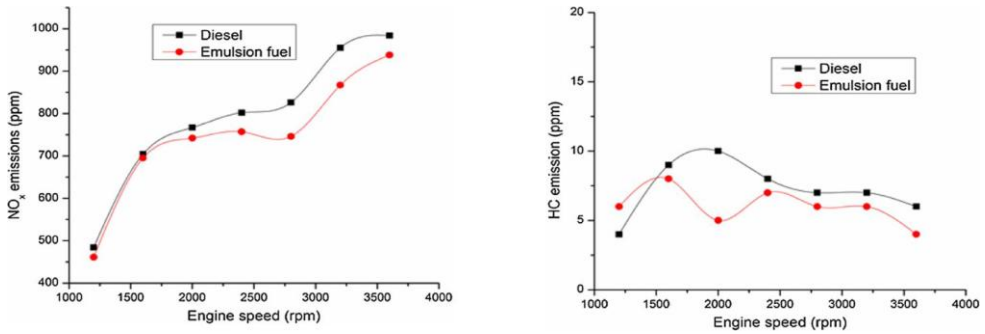

Fig. 7 NO^x and HC emissions of the engine fueled by emulsion fuel and pure diesel at full load[8]

Soot and PM is one of the major indicators of the combustion efficiency. The less formation of these emissions the more efficient the combustion of the tested fuel. From the various experimental results reported, the majority of the studies found that soot and PM are reduced by using the W/D emulsion fuel [7].

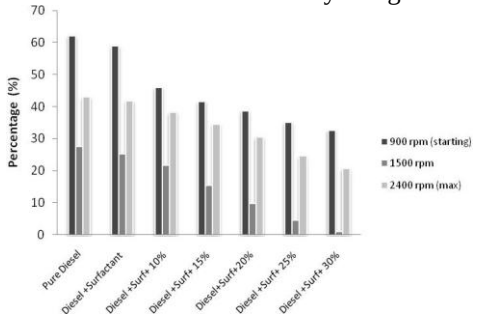

Fig. 8 Particular matters Reduction effect analysis [10]

V. Conclusions

From the reviews that were made, it can be concluded that:

I) Thermal efficiency is increased by using the W/D emulsion fuel compared to neat diesel fuel. The majority of the studies agreed that the improvement of the combustion efficiency is due to the increase of ignition delay and the micro-explosion phenomena.

II) Alternative fuels cover a broad range of fuels, some of which, including water-in-diesel emulsions are readily available, while other types require further investigations. Even if the water-in-diesel emulsion fuel has only a limited effect on the reduction of CO_2, it is still beneficial from an environmental point of view because it brings about a reduction in the levels of both NO_x and particulate matters (PM).

III) The engine torque, power and brake thermal efficiency increase as the water percentage by volume in the emulsion increases.

IV) Engine durability studies are required, as there may be a chance of clogging of the injector for long term engine operation.

References

[1] Anna Lif, Krister Holmberg (2006), Water- in –diesel emusions and related systems, advances in Colloid and Interface Science 123- 126 231- 239

[2] Cherng- Yuan Lin, Kuo- Hua Wang, Diesel engine performance and emission characteristics using three phase emulsions as fuel, Fuel 83(2004) 537-545

[3] Cherng-Yuan Lin, Kuo-Hua Wang, Effects of an oxygenated additive on the emulsification characteristics of two- and three-phase diesel emulsions, fuel.2003.08.014

[4] Ahmad Muhsin Ithnin, Hirofumi Noge, Hasannuddin Abdul Kadir, Wira Jazair , An overview of utilizing water-in-diesel emulsion fuel in diesel engine and its potential research study, Journal of the Energy Institute 87 (2014) 273–288

[5] E. Mura, P. Massoli, C. Josset, K. Loubar, J. Bellettre, Study of the micro-explosion temperature of water in oil emulsion droplets during the Leidenfrost effect, Exp. Therm. Fluid Sci. 43 (2012) 63–70.

[6] J. Schramm, R. Sigvardsen, M. Forman(2003), Bitumen/water emulsions as fuels for high-speed CI engines preliminary investigations, SAE Pap., 2003-01-31.

[7] W.M. Yang, H. An, S.K. Chou, K.J. Chua, B. Mohan, V. Sivasankaralingam, et al., Impact of emulsion fuel with nano-organic additives on the performance of diesel engine, Appl. Energy (2013).

[8] W.M. Yang H. An, S.K. Chou, K.J. Chua, B. Mohan, V. Sivasankaralingam, V. Raman, A. Maghbouli, J. Li, Impact of emulsion fuel with nano-organic additives on the performance of diesel engine, Applied Energy 112 (2013) 1206–1212

[9] Arun Kumar Wamankar, S. Murugan, Experimental investigation of carbon black-water-diesel emulsion in a stationary DI diesel engine, Fuel processing Technology 125 (2014) 258- 266

[10] Omar Badran, Sadeq Emeish, Mahmoud Abu-Zaid, Tayseer Abu-Rahma, Mohammad Al-Hasan, Impact of Emulsified Water/Diesel Mixture on Engine Performance and Environment, Int. J. of Thermal & Environmental Engineering Volume 3, No. 1 (2011) 1-7

[11] J.S. Basha, R.B. Anand, An experimental study in a CI engine using nanoadditive blended water–diesel emulsion fuel, Int. J. Green Energy 8 (2011) 332–348.

[12] B.D. Hsu, Combustion of water-in-diesel emulsion in an experimental medium speed diesel engine, SAE Pap. (1986), 860300.

[13] J.-K. Park, J.-M. Oh, H.-I. Kim, C.-H. Lee, K.-H. Lee, Combustion characteristics of MDO and MDO emulsion in automotive diesel engine, Trans. Korean Soc. Mech. Eng. B 36 (2012) 945–951.

[14] H. Sheng, L. Chen, C. Wu, The droplet group micro-explosions in W/O diesel fuel emulsion sprays, SAE Pap. (1995), 950855.

[15] A. Alahmer, J. Yamin, A. Sakhrieh, M.A. Hamdan, Engine performance using emulsified diesel fuel, Energy Convers. Manag. 51 (2010) 1708–1713.

[16] A. Bertola, R. Li, K. Boulouchos, Influence of water-diesel fuel emulsions and EGR on combustion and exhaust emissions of heavy duty DI-diesel engines equipped with common-rail injection system, SAE Pap. (2003), 2003-01-31

[17] Dan Scarpete, Diesel – water emulsion ,an alternative fuel to reduce diesel engine emission. A review, Machine, Technolologies, Mateirals. ISSN 1313-0226,2013.

[18] Suresh Vellaiyan,.S.Amirthagadeswaran, The role of water –in- diesel emulsion and its addities on diesel engine performance and emission levels: A restospective review , Alexandria Engineering Journal 2463-2472, 2016

