Applications of Emulsions as an Alternate Fuel for Bi-fuel engines- Review

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Abstract

The contemporary work describes the need of an alternative fuel due to rapid diminishing of petroleum products and it intensely concentrates on emission control. Generally, the diesel engine provides the efficient fuel to generate power at an economical rate so that diesel engines plays a vital role in mass transportation and ultimately creates pollution. To conserve environment and to derive the best performance, most of the research replace the diesel with various techniques such as blend, fumigation and emulsion. From literature survey come to know that Emulsion and fumigation exhibit a gradual reduction in NOx emissions. But emulsion shows higher CO and HC emissions when compared with the neat diesel.

Keywords: Emulsion, fumigation, blend, emissions.

1. Introduction

Diesel engines gives better efficiency compare to the other engines i.e. the reason most of engineering applications utilising the diesel engine. It plays vital role in the transportation sector and small scale electricity generating plant they cause the major environment pollution, then these are contributing most of pollutants like NOx, HC, CO, Particulate matter and greenhouse gas emissions. These emissions have been causes respiratory and cardiovascular problems, and neurodegenerative disorders. Moreover, they contribute the global warming with the CO2, it has contrary effect on weather change. Today, the global researchers are working mainly on three types of alternative biofuels they are, blending, fumigation and emulsion are in diesel engines for reducing the emissions and improvement of performance of diesel engine. The above three application techniques have been significant effects on engine performance and emission characteristics. The present paper covers the many research articles, the global researchers investigated to study the technical effects of blend, fumigation and emulsion on the engine performance and emission characteristics and to compare the results. And, Researchers around the world are tiresome possibilities to reduce peak combustion temperature without deteriorating the engine performance and reduce NOx emissions. Though, the in-cylinder systems, implemented to reduce NOx emission, but it causes to increase smoke, if take an exhaust gas recirculation(EGR) it reduces NOx emission but increases particulate emission.

1.1 Blend

Blend is the mixture of biofuel and diesel with in the desired proportion based on physicochemical properties, it is mostly used as dual fuel method in compression ignition engines. Generally, different additives like co-solvents are added to biofuel-diesel blending to ensure the miscibility of blend and to get the stability. Psychochemical properties of biofuel and diesel are different so that blending of such fuels may vary in key fuel properties like viscosity, density and cetane number.

1.2 Emulsion

Emulsions, existence of liquids, does not exhibit a static internal structure. Generally, it is a process of mixing two immiscible substances, in emulsion mode, one substance i.e. the dispersed phase is uniformly distributed throughout the second substance i.e. the continuous phase. A small quantity of surfactant is used in the range 1–5% for stabilize the emulsion. A surfactant is a substance that is that lower the interfacial tension between two liquids. the micro-explosion phenomenon in the emulsified
fuel is caused by the volatility differences between water and Diesel fuel. Based on the applications of emulsion vary the stability time, mostly it depends on several factors as stated below.

1.2.1 Based on droplet size

The droplet size of dispersed substance, emulsions are categorised in to three types [22]

Macro emulsions

Macroemulsions are significant category, the size of particle is more than 400nm. In macroemulsions dispersed phase particle size is higher, so the interfacial surface per unit volume is lesser.

Micro emulsions

Micro emulsion is a thermodynamically stable, the size of particle is in between 100 and 400nm (0.1–0.4μm). These emulsions take more time to prepare and mostly it is used in pharmaceutical industry.

Nano emulsions

Nano emulsions are transparent and kinetically stable. The particle size is less than 100nm (0.1 μm). Unlike micro-emulsions, these are principally adapted for the generation of nanomaterials.

1.2.2 Based on phase

Emulsions are again classified into two categories based on the phase these are Two-phase emulsion and Three-phase emulsion.

Two-phase emulsion

The two-phase emulsion is formed by mixing two inherently immiscible fluids. The common types of Two-phase emulsions are water-in-oil (W/O) and oil-in-water (O/W) emulsion, W/O emulsion, a small quantity of water is the dispersed in a large volume of oil, the schematic diagram shows in Fig.1. it is considered as an alternative to diesel.

![Figure 1. Two phase Water in oil emulsion](image1.png)

Three-phase emulsion

In this three-phase emulsion the inner and outer phases are detached by a dispersed phase. Generally, three-phase emulsions are also known as "multiple emulsion". The three-phase emulsion structure can be shown in the Fig. 2. Most of the researchers used three types techniques for preparing the three-phase emulsions these are (a) two-stage emulsification, (b) mechanical agitation, (c) phase inversion.

![Figure 2. Three-phase oil-in-water-in-oil emulsion](image2.png)
1.3 Fumigation

A high octane gaseous fuel is injecting in to the intake manifold and it mixes with fresh air then forms high octane gaseous mixer is called the fumigation technique. In fumigation system, a gaseous fuel injects into the intake air stream by spraying or carburettion to a CI engine. The gaseous mixer burns and becomes contributor to the power producing. While alcohol, hydrogen and natural gas may be used as gaseous fumigation for improve the performance and emissions benefits. Generally, the fumigation process is carried by two categories are.

Major fraction fumigation

In major fraction fumigation, more than half (50%) of the gaseous fuel is injecting into the intake manifold.

Minor fraction fumigation

In minor fraction fumigation, less than half (50%) of the gaseous fuel is injecting into the intake manifold.

Based on phase

Emulsions can again be classified broadly, into two categories. These are two and three-phase emulsions.

1.4 Fumigation with Emulsion

The diesel engine fuelled with emulsion as pilot fuel and gaseous fuel as primary fuel, the primary fuel injects into the intake air stream. These technique shows an effective result on performance parameters and emission control compare with the single fuel mode of operations.

2. Materials and Methods

The most of global researchers are working on compression ignition engine. They are used different emulsified fuels for reducing emissions. Moreover, emulsified fuel in a diesel engine is the water in diesel emulsion. Along with, the emulsions prepared with waste cooking oil (WCO), animal fat, methanol, ethanol and rapeseed methyl ester, etc., emulsified biodiesels are used, to prepare and stabilize the emulsions researchers are adopted different techniques. Generally, the stability of the emulsion fuel depends on emulsification technique, process duration, concentration of water, stirrer speed and surfactant concentration. T. Korakianitis et al [9] used mechanical emulsifier it consisting of an electric motor driving a chopper blade inside a mixing chamber. Yanan Xu et al [21] utilise the span 80 and tween 80 as surfactant and dry algal cells were grinded then mixed with reference quantity of diesel. M. Abu-Zaid [12] used an electrical blender at a speed of 1500 rpm for preparation of water diesel emulsion stabilize the emulsion by 2% volume of surfactant mixture containing the span 80 and tween 80. Dolanimi Ogunkoya et al [15] worked for producing the stabilized emulsions, they added 0.5% carboxymethylated lignin with water and then fuel is mixed by using of ultra-turrax at 20,000 rpm.

The researchers are implemented various techniques for fuel induction in the cylinder such as carburation, timed manifold/port injection (TMI), direct hydrogen injection (DHI) and continuous manifold induction (CMI) [10]. In the dual–fuel engine gaseous fuels are directly injected into the inlet manifold inducted through a flow meter along with air stream of engine’s own suction. Bhaskor J. Bora et al [4] modified existing diesel engine into dual fuel operation by connecting a venturi gas mixer in the inlet manifold and the pilot fuel supply under dual fuel mode (DFM) limited by installing a fuel control mechanism (FCM). The biogas flow rate is operated by a biogas flow meter. Senthil Kumar et al [20] tested engine performance and emissions by using hydrogen as primary fuel and waste cooking oil as pilot fuel. A.M. Namasiyayam et al [14] operated the dual fuel engine using rapeseed methyl ester emulsion as pilot fuel and natural gas as primary fuel and the load was controlled by regulating flow rate of natural gas. Induced by the engine.

Generally, Cylinder pressure and crank angle variation are measured by using of a high-speed digital data acquisition system in conjunction with a piezoelectric transducer, various exhaust gas species were measured via a heated line using a Signal 4000 VM chime-luminescence NOx analyser, Analysis Automation non-dispersive infrared CO and carbon dioxide analysers, and a Servomex.
paramagnetic oxygen analyser. Unburnt HC was measured via a heated line at 160 °C by a Rotark FID analyser.

3. Analysis of engine Performance, Emission and Combustion characteristics of Emulsion based Bi-Fuel engine, Fumigation and Emulsion

The use of biodiesel is rapidly growing around the world and understand the effects of biodiesel on the diesel engine combustion and emission formation. The brake specific fuel consumption play a vital role on engine performance. M. Senthil Kumar et al [20] worked on compression ignition engine using waste cooking oil (WCO) emulsion as pilot fuel and hydrogen as primary fuel, it shows 30.3% improvement in brake thermal efficiency when 10.5% hydrogen energy share at full load condition and HC emissions are also reduced by 50% when compare with the neat WCO, but it observed that NOX emissions were slightly higher. T. Korakianitis et al [9] operated the dual fuel engine rapeseed methyl ester emulsion as pilot fuel and gaseous hydrogen with a purity of 99.995%, they found that emulsified pilot fuels increase thermal efficiencies compared with the neat RME pilot fuel at higher engine speeds, because of micro explosion phenomenon. Hydrogen dual-fuel operation exhibits the lower power output because of gaseous fuel injects into inlet manifold but it gives the engine stability and avoid knocking. Hydrogen dual-fuel operation with emulsion pilot fuel increases NOX emissions at higher loads. A.M. Namasiyam et al [14] worked on gaseous high-cetane fuel and water diesel emulsion were tested as pilot fuels during dual-fuel combustion with natural gas. They were found that at 1000r/min for low loads, pilot fuel emulsification reduced NOX emissions by about 20% and emission movements are usually shown as function of equivalence ratio. Dual-fuel combustion with natural gas Increased HC and CO emissions and it gives low thermal efficiencies. Because of the air fuel mixture is diluted with the water vaporisation so that it formed cooling effect and another one was the micro explosion phenomenon which enhances fuel air mixing.

3.1 Fumigation

A.E. Dhole et al [6] research on dual fuel engine with different substitution of H2, Producer gas (PG) and mixture of PG and H2 respectively. They found that brake thermal efficiency is improved by 7% when 20% hydrogen as used as secondary fuel and 8% brake thermal efficiency is decreased by using 30% PG is used as secondary fuel. Mixture of PG and H2 (in the ratio 60:40) reduces 3% of BTE. Hu´seyin Turan Arat et al [1] main goal of work was to run a conventional diesel engine enriched with HHO-CNG mixture. They found that the average improvement of HHO+ Pilot diesel was 3.4% and 25HHO+CNG +Pilot diesel was 6.28% when compare with the neat diesel. D.B. Lata et al [11] investigated on dual fuel engine with hydrogen, liquefied petroleum gas (LPG) and mixture of LPG and hydrogen as secondary fuels, conclude that 17% brake thermal efficiency was enhanced by 30% hydrogen used as secondary fuel, 6% brake thermal efficiency was enhancement was observed using 40% LPG used as secondary fuel. HC and CO were reduced in both cases and observed slight decreasing in NOX and smoke. Mixture of hydrogen and LPG shows 27% improvement of thermal efficiency and found that 68% reduction in HC emission. Premkartikkumar et al [19] studied the effect of oxygen enriched hydrogen-HHO and it shows an improvement of brake thermal efficiency by 11.06%, reduced carbon monoxide and unburned hydrocarbon by 15.38% and 18.18% respectively. But it shows increasing of carbon dioxide by 6.06% and NOX emissions by 11.19%.

3.2 Emulsion

Mohammad Reza Seifi et al [18] worked on water–diesel emulsions. Their data shows that engine power is significantly increased for 2% water addition emulsion and engine speed and fuel types were shows significant effect on engine noise emission. O. Armass et al [3] worked on the effect of water–oil emulsions, it shows improves the engine efficiency in certain operating mode and found the significant reduction NOX, HC compare with neat diesel. M. Abu-Zaid [1] conducted the experiments on A single cylinder Diesel engine and used the fuel as emulsified diesel and reported the 3.5% improvement in brake thermal efficiency and exhaust gas temperature was reduced by increasing the water percentage in the emulsion. Niko Samec et al [17] done the Numerical and experimental study on water/ oil emulsified fuel combustion characteristics. From the results obtained
they suggested that Water/Oil can be successfully controlled heavy-duty diesel engine exhaust pollutant emissions, especially NO\textsubscript{X} and soot. Unconventional technique to decrease NO\textsubscript{X} and soot emissions in diesel engine is a quite appropriate method to be working on vehicular diesel engines for special purposes working mostly in urban area or on stationary engines.

4. Conclusions

The above literature gives some knowledge about different methods used in alternative fuels. It was used for investigate the performance, combustion and emission characteristics of diesel engines. Based on suggestion process, there are some differences among the results. After completion of literature survey wished for the following conclusions.

i) Blend, fumigation and emulsion, each of them increase the Brake specific fuel consumption.

ii) Emulsion with fumigation technique gives better efficiency compare to single fuel mode.

iii) In blend mode, NO\textsubscript{X} emissions are more because of high temperature in combustion chamber.

iv) NO\textsubscript{X} emissions are controlled by using the emulsification technique.

v) Less amount of hydrogen can be inducted with air to progress the performance and decrease emissions of diesel engine with water diesel emulsion as fuel.

vi) Smoke opacity and particulate Matter emission decrease significantly in biofuel blend.

References


