MATRIX ACADEMIC INTERNATIONAL ONLINE JOURNAL OF ENGINEERING AND TECHNOLOGY
ISSN: 2348-3326

Volume 3, Issue 2

An experimental investigation of impact of emulsified fuel on exhaust emission of diesel engine.

Hiren V. Mandalia

Mechanical Engineering Department
Government Polytechnic
Jamnagar, India.
hvmandalia@gmail.com

***Abstract*— Presently almost all commercial transport vehicle used Diesel engine, so it's become a major power source in the transportation sector as well as in individual transport. Due to widely use of diesel engine it plays an important role in the man-made emissions. Nowadays developed technologies are used to reduce the consumption of fuel and exhaust emission of a diesel engine. Due to which the fuel consumption in a CI engine is reduced to a considerable amount, but the emission of smoke, HC and CO is a critical issue. This paper tries to shows the opportunity of using emulsified fuel and its impct on exhaust emission from CI engine.**

***Keywords*— Emulsion, , Diesel engine, Emissions**

I. INTRODUCTION

Nowadays automobiles play an important role in the transport system anywhere in the world. With an increase in population and living standard, the transport vehicles as well as car population is increasing day by day. For heavy duty application such as on-road, off-road, marine and industrial usage Diesel engines, particularly direct injection types, have been an important choice due to their high brake thermal efficiency. A high cetane fuel is injected into the cylinder of diesel engines, which further mixed with air.[1,3,] In diesel engine fuel-air mixture burns under high pressure condition.(compression ignition) As far fuels in diesel engines are concerned, there are many alternatives that can be used as a fuel for diesel engine. The alternative fuels like vegetable oil, hydrogen, biomass, liquefied petroleum gas, alcohol, compressed natural gas etc. are being used them in dual fuel modes or directly without any engine modification or any problems. With the increasing interest about the green house effects on the atmospheric conditions, compared to gasoline engine lower CO2 emission of diesel engine (about 30%), remains an advantage. High power output and reduced smoke and other exhaust emissions from diesel engine is now possible due to supercharging, which is extensively used on stationary and mobile applications. On the reverse side the diesel engines emit smoke, high oxides of nitrogen, and particulate emissions in exhaust.[5] The pollutants from diesel engine can be classified into two types as visible and invisible emissions. Visible emission is the smoke which is objected more by the public. The invisible emissions include CO, HC, NOx, SO2, and odours. The type of the engine and speed of the engine are two main factors which influence the exhaust emission from a diesel engine.[4]

II. EMISSIONS FROM DIESEL ENGINE

The pollutants from diesel engine can be classified into two types as visible and invisible emissions. Visible emission is the smoke which is objected more by the public. The invisible emissions include CO, HC, NOx, SO2, and odours. The type of the engine and speed of the engine are two main factors which influence the exhaust emission from a diesel engine.[4]

A. NOx Formation

Among the gaseous pollutatants emitted by the diesel engine, NOx are the most significant. NOx is referred to here as mixtures of nitric oxide (NO) and nitrogen dioxide (NO2).These are generally formed at high temperature. Hence higher temperature and availability of free O2 are the main two reasons for the formation of NO and NO2.Supply of more air reduces the peak temperature and therefore NOx concentration falls ever free O2 is available. [4]NOx emissions are controlled because NO and NO2 contribute to the formation chemistry of low-level ozone, or smog, an environmental and human health hazard. NO2 is also directly of concern as a human lung irritant.

B. CO Formation

CO is formed when there is insufficient O2 to oxidize the fuel fully during the combustion of fuel. The amount of CO formed in diesel engine is considerably lower than petrol engine because always excess air is supplied to the engine. Theoretically, diesel engine should not emit CO at all as it always operated with excess air. But CO is present in small quantities in diesel exhaust and sufficient O2 due to local depletion in certain parts of the combustion chamber. The percentage of CO in exhaust varies from 0.1% tp 0.75%.[6]

C. Hydrocarbon (HC)

HC emissions from diesel engine are also significant. Presence of carbon particles in the flue gas is the cause of the black smoke in diesel engine exhaust, especially during racing periods. The concentration of the HC in the diesel engine exhaust varies from a few ppm to several thousand ppm depending upon the load on the engine and its speed. It is

ISSN: 2348-3326

Volume 3, Issue 2

mainly formed due to incomplete combustion of the fuel or improper mixing of fuel and air. A greater surface to volume ratio of the combustion chamber leads to the formation of greater fraction of hydrocarbon from quenched zone.[9]

D. Particulate Matter

Diesel derived particulates, because of their chemical composition and extremely small size, have raised a host of health and environmental concerns. When released into the atmosphere, DPM can take the form of individual particles or chain aggregates, with most in the invisible sub-micrometer range of 100 nanometers, also known as ultra fine particles Particulate matter (PM) consists mostly of three components: soot formed during combustion, heavy hydrocarbons condensed or absorbed on the soot, and sulfates. In older diesel engines, soot was typically 40% to 80% of the total particulate mass.[10]

E. Smoke

Smoke in the exhaust gases is the indication of incomplete combustion. Smoke from exhaust is a visible signal of the incomplete combustion process. It is generated at any volume in the engine where mixture is rich. Due to incomplete combustion soot is formed. Once soot is formed, it can burn if it finds sufficient O_2 otherwise it comes out with the exhaust. It becomes visible if it is dense. There is no visible smoke under most operating conditions from the exhaust, if the diesel engine is in good working condition. When an engine is accelerated under load there may be a short puff of smoke which can be acceptable. For past diesel engine in which older technology was used, due to the lag before the air flow and turbocharger speed it's not possible to match the volume of diesel injected into the cylinders. [8]

III. EMULSION

Emulsified Fuels are emulsions which contain water and fuel. Emulsions are a distinct case of a dispersion comprising a continuous and a dissolved phase. In emulsions there exist both phases of immiscible liquids, oil and water. Emulsion fuels can be either an ordinary emulsion or a microemulsion. (sometimes known as macroemulsion, to discriminate them from microemulsions). As there is a difference in density of both the liquid they are not miscible naturally. To mix them surfactant is required. It is the surfactant which reduce the surface tension of both the liquid by covering the both the liquid at molecular level. Which makes possible to mix one into another.

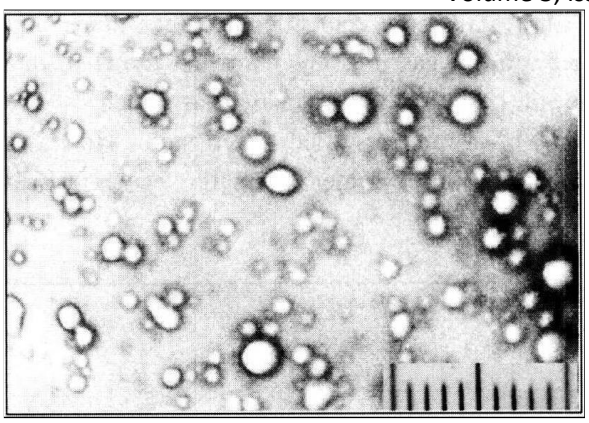

Fig.1 Photograph of Emulsified fuel

Fig. 1 shows photograph of emulsified fuel. Microemulsions are isotropic whereas macroemulsions are prone to settling and changes in particle size over time. Both use emulsifiers (also called surfactant) and can be either oil-in-water (regular emulsions) or water-in-oil (invert emulsions), or discontinuous emulsion, which is molecular dispersion in which both the dissolved phase and the dispersion medium are liquids.[7]

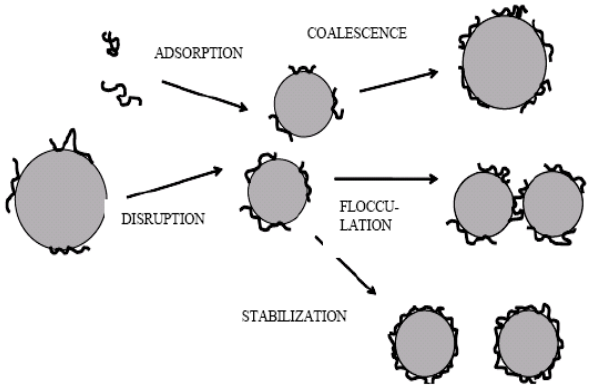

Fig.2.Process involved in emulsification of oil droplet in water phase with stabilizer

Fig.2 shows process involved in emulsification of oil droplet in water phase with stabilizer. There are mainly two types of emulsified fuels. One is water-in-diesel fuel in which diesel fuel is in continuous phase. A second type is diesel fuel-in-water.[1] The main benefit of the water emulsified diesel is that the heat is absorbed due to the vaporization of water which causes a decrease of local adiabatic flame temperature and due to which there is a reduction in the chemical reaction in gas phase to produce thermal NO. [7]. Also there is a slightly reduction in brake power output while adding water. The addition of water may have caused the delay in ignition period which may caused the pressures to increase before the top dead center. Due to this there chance in increase of the compression work and reduction in the net work of the cycle which produces less power output. But overall against the

ISSN: 2348-3326

Volume 3, Issue 2

benefit of reductions in emissions from diesel engine this very low reduction in power output can be tolerated.

IV. COMBUSTION OF EMULSIFIED FUEL

Kadota T.[6] shows that water fuel emulsion consists of base fuel (pure diesel) and amount of water with or without a trace content of surfactant (called surface active agent). Whether emulsion will be micro- or macro-emulsion is depend on the type of surfactant is used. The macro-emulsion looks milky and opaque, and consists of fine droplets dissolved in the continuous phase of another liquid. Generally, more surfactant (surface active agent) is required to make a micro-emulsion. A number of possible gain are offered in the combustion of emulsion. It is expected that the involvement of water in the evaporation process leads towards reduction of the droplet temperature.

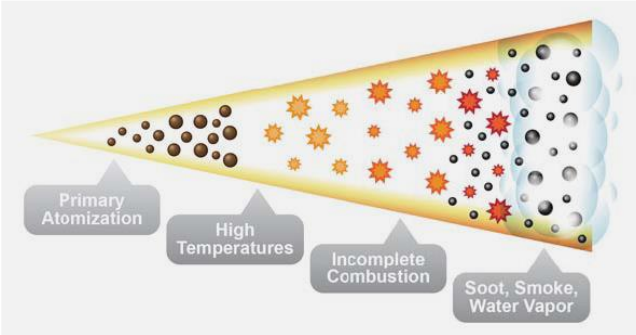

Fig.3 Base Fuel Combustion

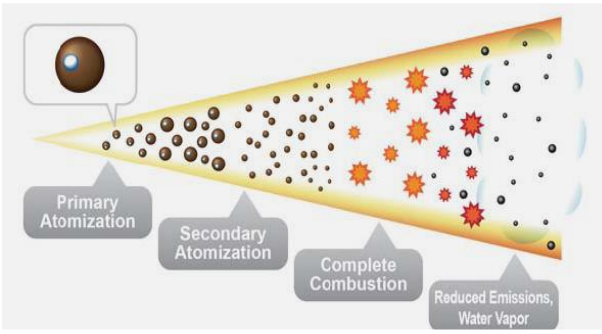

Fig.4 Emulsified Fuel Combustion

Fig. 3 and fig.4 shows the combustion of base fuel and emulsified fuel. The emulsion is essentially a multi-component fuel that its base fuel and water are not miscible at the molecular level. The combustion of emulsion droplet is frequently accompanied by the microexplosion which is not common in the combustion of pure diesel's droplet. This micro-explosion which caused secondary atomization of the fuel is caused by the volatility difference between the base fuel and water. The interior water and/or base fuel become superheated as the emulsion droplet is heated by convective and radiative heat transfer from surrounding combustion gas and flame during combustion.[9]

V. EXPERIMENTAL SETUP

For the purpose of this experiment a single-cylinder, 4-Stroke, water-cooled diesel engine of 5 hp rated power is used .

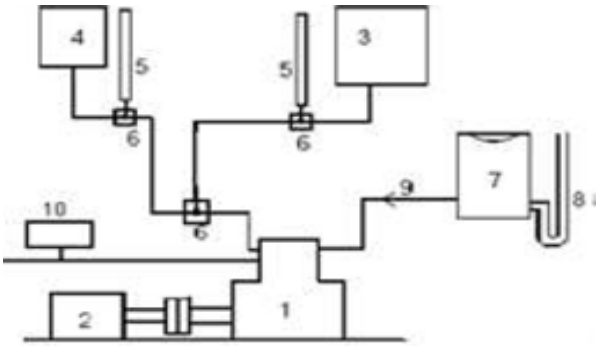

Fig. 5 Experimental set up

1. Engine 2. Dynamometer 3. Fuel tank for diesel 4. Fuel tank for emulsified diesel 5. Flow meter 6. Three way valve 7. Air box 8. Manometer 9. Airflow direction 10. Exhaust analyzer

A rope brake dynamometer is used to coupled with engine through a load cell. The schematic layout of the experimental set up is shown in Fig. 5.

For this investigarion direct injection stationary diesel engine of 5HP is used. Whose specifications are shown in below mentioned Table.

Table1 Engine Specification

Parameter	Details
Engine	Single Cylinder High Speed Diesel Engine
Cooling	Water cooled
Bore × Stroke	80 mm × 110 mm
Compression ration	16 : 1
Maximum Power	5 hp
Rated speed	1520 rpm

VI. RESULTS AND DISCUSSION

In this phase of experimental work, the engine was operated on diesel fuel with different percentage of water. Methodology used was identical with that of high speed diesel operation with respect of change of loads, recording of fuel consumption, exhaust emission and various temperatures.

Experiments were conducted on four different samples of emulsified diesel.

The following different samples were tested on the engine.

1. 95% diesel and 5% water.
2. 90% diesel and 10% water.
3. 85% diesel and 15% water.
4. 80% diesel and 20% water.

Results shows that there is a considerable improvement in engine performance and emissions.

A. Smoke density

ISSN: 2348-3326

Volume 3, Issue 2

Results shows that there is a reduction in smoke density while using emulsified diesel compared to neat diesel. Which shown in figure 6.

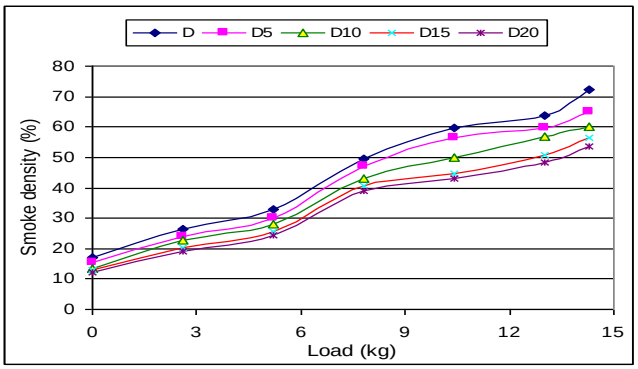

Fig.6 Load Vs. smoke emission

The data from observation table shows that the lowest smoke was found in exhaust gases from the engine when it was operated using emulsified fuel D20 (20% water contents) followed by the emulsified fuel with D15, D10, D5 em- fuel and pure diesel. Because of lower smoke of emulsified diesel its exhaust is less dark than the pure diesel.

B. HYDROCARBONS (HC)

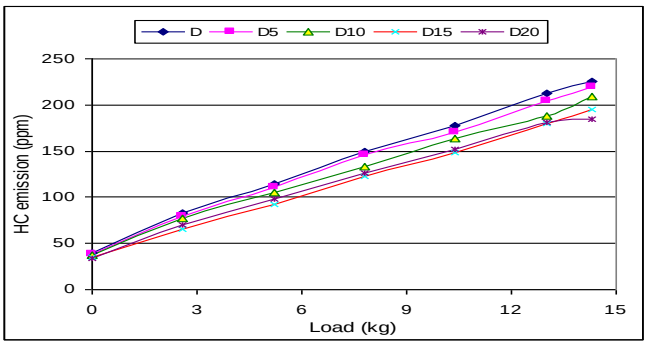

Fig.7 Load Vs. hydrocarbon emission

It is clear from the figure 7 that the amount of hydrocarbon (HC) in exhaust gases is lowest while using emulsified fuel with 5% of water followed by 10%, 15% and 20% of water.

At all load conditions the presence of HC in exhaust gases is found decreasing with increase in water percentage in the emulsion. Figure indicate that 15% em- fuel gives lowest HC emission followed by 20%, 10%, 5%, and pure diesel. For overload condition D20 gives lowest hydrocarbon emission. This observation is consistent the literature review. It is the micro-explosion phenomenon in emulsified fuel which cause secondary atomization which further leads to better fuel-air mixing in the combustion chamber. Due to improved and better mixing of fuel with air exhaust shows reduction in HC.

C. CARBONMONOXIDE (CO)

Fig.8 shows the amount of CO present in exhaust gases of diesel engine using emulsified fuel with different percentage of water in it and neat diesel. Results shows that emulsified diesel which contain 15% water shows lowest emission of Carbonmonoxide (CO). Which is followed by 20%, 10% and 5%. It is only because of better mixing of air and fuel which further leads to improved combustion. At higher load 20% water content gives lowest emission followed by 15%, 10%, 5% and pure diesel. It is clear from the figure that there is a considerable reduction in CO emission as compared to neat diesel. . It is only due to the micro explosion during the burning of emulsified fuel, which further increase degree of mixing of reactant mixture.

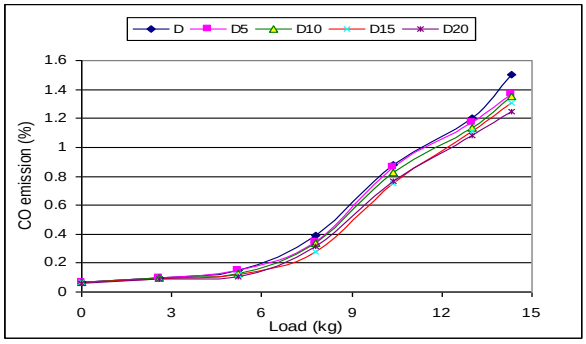

Fig.8 Load Vs CO emission

VII. CONCLUSIONS

Presently almost all commercial transport vehicle used Diesel engine. Exhaust from CI engine contains CO, HC, NOx,CO2 and PM. It is concluded that, while using emulsified fuels its emissions shows lower CO emissions as compared to neat diesel. It is only due to the micro explosion during the burning of emulsified fuel, which further increase degree of mixing of reactant mixture. Emulsified diesel with 15% gives lowest emission. Results shows that from no load to full load conditions the presence of Hydrocarbon in exhaust gases is found decreasing with increase in water percentage in the emulsion. It is found that 15% em- fuel gives lowest HC emission, which is followed by 20%, 10%, 5%, and pure diesel. Also lowest smoke was found in exhaust when engine was operated using D20 emulsified fuel (20% water contents). Which is followed by the emulsified fuel with D15, D10, D5 em- fuel and pure diesel.

REFERENCES

[1] Alahmer, J. Yamin, A. Sakhrieh and M. Hamdan,(2009). "Engine Performance using emulsified diesel fuel." Energ. Convers. Manage, 51(8): 1708-1713. doi: 10.1016/j.enconman.2009.11.044.

[2] Anna Lif a, Krister Holmberg, (2006) "Water-in-diesel emulsions and related systems" Advances in Colloid and Interface Science 123–126 Pg.no. 231–239.

[3] Brown Kevin,John Chadderton, Daniel T. Daly,Deborah A. Langer, David Duncan(2000) "Opportunity for Diesel Emission Reductions Using Advanced Catalysts and Water Blend Fuel" SAE technical paper series - 2000-01-0182.

[4] Domkundwar " A course in Internal Combustion Engines"

[5] Environmental Protection Agency, United States, "Impacts of Lubrizol's PuriNOx Water/Diesel Emulsion on Exhaust Emissions from Heavy-Duty Engines Draft Technical Report", EPA420-P-02-007 December 2002.

[6] Jae, W.P., Y.H. Kang and H.P. Kweon,(2000), "Experimental study on the combustion characteristics of emulsified diesel in a RCEM." Seoul 2000 FISITA World Automotive Congress. June 12-15, Seoul, Korea Paper No. F2000A073.

[7] Jamil Ghojel, Damon Honnery, Khaled Al-Khaleefi.(2006). "Performance, emission and heat release characteristics of direct injection diesel engine operating on diesel oil emulsion." Applied Thermal Engineering. 26: 2132-2141.

[8] Jarno-petteri merisalo, (2009) "Optimization of ASA emulsification in internal sizing of paper and board", Thesis for the degree of Master of Science in chemistry and materials sciences, Helsinki University of Technology.

[9] Kadota T., Yamasaki1 H.(2002) "Recent advances in the combustion of water fuel emulsion", Progress in Energy and Combustion Science 28, 385–404

[10] Kannan K., Udayakumar M. (2009) "NOx and HC emission control using water emulsified diesel in single cylinder diesel engine" ARPN Journal of Engineering and Applied Sciences, VOL. 4, NO. 8, ISSN 1819-6608