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PERFORMNCE AND EMISSION ANALYSIS OF DIESEL ENGINE USING EMULSIFIED MUSTARD BIODIESEL

Dr. K. Kalyani Radha[1] Dr. B. Omprakash[2] ,
1. Associate Professor, *Dept. of Mech Engg, JNTUACEA, Ananthapuramu, A.P, INDIA.*
2. Associate Professor, *Dept. of Mech Engg, JNTUACEA Ananthapuramu, A.P, INDIA*

Abstract: **Increase of automobiles across the world and decrease of fossil fuels created an interest to arrive at an alternate fuel for the diesel locomotives. Among many solutions offered, recent developments are with emulsified fuels. For cutting out the emissions Water Diesel Vegetable oil (W- D –V) emulsions are identified as suitable fuels. The water content in the emulsion has the ability to lower the combustion generated pollutants and increase the combustion efficiency. Vegetable oils are also a very hopeful alternate fuel for diesel engines because they are renewable, clean burning and have properties analogous to that of diesel. In the present study Mustard oil biodiesel produced by transesterification process is used in Water Diesel Biodiesel emulsion and the performance and emission characteristics by using Water Emulsified Mustard Biodiesel and pure diesel in varying proportions on volume basis are analysed and various parameters such as Brake Power , Fuel consumption, Mean effective pressures are calculated .The test results indicate that the blend WDV 20 % (Water 10 % + biodiesel 20% + diesel 70%) gives better performance and reduced emission compared to all emulsified fuel mixtures and diesel**

KEYWORDS: Performance, emulsification, Biodiesel blends.

I. INTRODUCTION

Diesel Engines are employed in heavy duty applications for a very long time now; it is only recently that it has become very popular in light duty applications owing to their high fuel efficiency. Higher fuel efficiency in the diesel engines is achieved due to the high compression ratios along with high oxygen concentration in the combustion chamber .However the same factors results in higher NO_X emissions in diesel engines .The stringent emission norms have been an important driving force to develop the internal combustion engines in a more environmental friendly way. The main pollutants from the diesel engine are NO_X, HC, CO, PM and SMOKE [1]. Researchers have tried to cut back the emissions and improve the fuel conversion efficiency of diesel engines. One promising method may be the use of water emulsified bio diesel which can economically accomplish both the goals. Addition of water in any kind of emulsion had a positive effect on the combustion efficiency of the engine, water added to the fuel lowers the combustion temperature due to the water evaporation .When the water within the fuel – water emulsion evaporates, the surrounding fuel is vaporized as well .This increases the surface area of the fuel by dispersing a finer mist .The lower temperature and the better fuel distribution result in reduced NO_Xemissions.The brake thermal efficiency increase and brake specific fuel consumption is found to decrease as the amount of water in the emulsion increased [2]

Emulsion: An Emulsion can be defined as a mixture of two liquids in which one is present in droplets of macroscopic or ultra-macroscopic size, distributed throughout the other .Emulsions are made from the constituents spontaneously or by a mechanical way .In spontaneous emulsions ,the mixing is easy and spontaneous . But if they don't mix properly a third chemical called Surface active agents or Surfactants is used to bind the molecules of the constituent liquids.

II. LITERATURE SURVEY

K.Kannan*et al [1]* have worked on NO_x and HC emission control using single cylinder engine. This paper reports on the effects of water emulsified diesel fuel combustion on the brake thermal efficiency, brake specific fuel consumption and NO_X and unburnt hydrocarbon emissions in a diesel engine. Experiments were conducted on a single cylinder four stroke cycle direct injection diesel engine running at a constant speed with a fuel injection pressure of 200 bars. Tests were done using commercial diesel fuel and emulsified diesel fuel with 10% and 20% water by volume .From the test results, it was found that the water emulsification has a potential to improve brake thermal efficiency and brake specific fuel consumption. The NO_X and hydrocarbon emissions were found to decrease with increase in water percentage in the emulsified diesel.

Agung S *et al* [2] attempted to study the use of diesel oil-water emulsion fuel (water in-oil type) in direct injection single cylinder diesel engine. The laboratory experimental project used 10% water that was mixed with Diesel Oil (DO) and in a few of inorganic surfactant by volume ratio (10% water, 89% diesel oil, 1% surfactant). To produce blending fuel the above mentioned components were mixed in a mechanical mixer controller. During the blending process the special surfactant will make oil surround the water droplet to prevent the water from separating out of the mixture. The encapsulation of water in oil which are in micro meter sizing prevents the water from contacting any metal engine parts. The experiment was conducted with single cylinder diesel engine set-up at 2000 rpm with variable engine load. Measurement of engine emissions parameters at different load conditions generally indicated reduction in engine carbon monoxide, sulphur dioxide and nitrous oxide emission as compared to base diesel oil

Pradeep Kumar*et al* [3] carried out an experimental investigation on diesel-water emulsion as a fuel in direct injection diesel engine. The water content varied by 5% and 8% with diesel fuel. He found that the thermal efficiency was increased by 4.59 and 2.48, respectively. There was a decrease in smoke opacity emission by 7.54 and 3.92 with the emulsified

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fuels. He also reported that an appreciable decrease inNO_X emission by 28.52% and 24.48%. The conclusion implied that diesel-emulsion could be a suitable alternative fuel, as it reducesNO_X and smoke simultaneously.

Prakash et al [4] investigated the performance, combustion, and emission parameters of a diesel engine fueled by wood pyrolysis oil (WPO) diesel emulsion with Diethyl ether (DEE) as an ignition improver. They carried out the research work, with three fuels in DI diesel engine and a little amount of (2% and 4%) DEE also added with WPO diesel emulsions. They compared and analyzed the results with the diesel fuel. The brake thermal efficiency was found to be higher by 6.34, 9.5, and 9.3 percent for WPO diesel emulsion, WPO diesel emulsions with 2% and 4% DEE respectively when compared with diesel fuel at full load. The percentage reductions in NO emissions for WPO diesel emulsions were observed as 19.21, 28.38, and 34.81.

Based on the literature survey, it is observed that emulsified fuel is one of the effective methods for cutting out the exhaust emissions. Utilizing water as an additive, reduces the formation of $NO_X$and HC emissions to a greater extent.Tests are carried out on diesel engine and the performance and emission characteristics are analyzed with pure diesel and emulsified mustard biodiesel with different proportions on volume basis.

II. MUSTARD OIL

Bio diesel is analternative to petroleum – based fuels derived from vegetable oils, animal fat, and used cooking oil including triglycerides. Since the petroleum crisis in 1970, the rapidly increasing petroleum prices and uncertainties concerning its availability growing concern of the environment and the impact of greenhouse gases during the past two decades has received more and more interest in the use of the bio diesels as a substitute for fossil fuel [3]Bio diesel is produced by chemically reacting a vegetable oil or animal fat with an alcohol such as methanol. The reaction requires a catalyst, usually a strong base, such as sodium or potassium hydroxide, and produces new chemical compounds called methyl esters. It is these esters that have come to be known as biodiesel. Depending on the free fatty acid (FFA) content of oil, conversion of any vegetable oil into biodiesel can be carried out using the method of Lipid Transesterfication process.[4] 1. Take 100 ml of oil in a beaker and preheat the oil to 60^0C in heating mantel 2.Take 500ml beaker add the preheated oil and place it on a magnetic stirrer 3.Add 30ml of methanol to oil present in the beaker.4.Add 1gm of sodium hydroxide 5. Stir the mixture at 300rpm for about 2hrs maintaining at 60^0C.6. After complete stirring pour the oil in a separating funnel for 24hrs. 7. Collect the oil present at the top of funnel.7.Drain out the glycerin that settles down at the bottom as thick cloudy liquid .The oil that present at the top is methyl ester or bio diesel. Washing of Biodiesel is necessary to remove the soluble components using hot water. Hot water is sprayed on top of the biodiesel. Then it is allowed to settle down and waste water is drained off. The washing is carried out 3-4 times to get pure biodiesel.

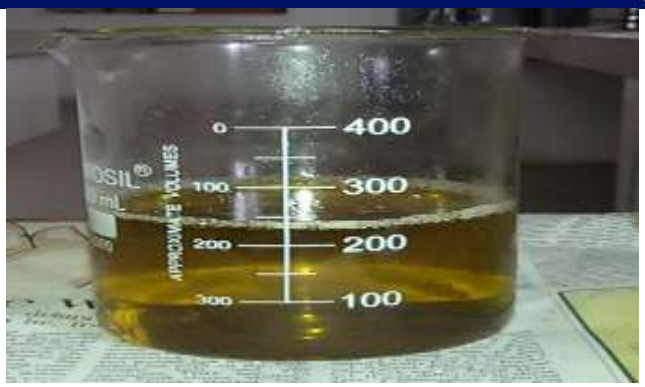

Figure 1: Mustard oil

Table 1: Properties Of Biodiesel

Property	Diesel	Biodiesel
Density (Kg/m^3)	850	886
Colour	colourless	Yellowish
Kinematic viscosity at 40^0c (m^2/sec)	$(2.5\text{-}6)\times10^{-6}$	$(9.6\text{-}6)\times10^{-6}$
Flash point (^{o}c)	51	187
Calorific value (MJ/Kg)	42	38
Specific gravity	0.85	0.89

III. EXPERIMENTAL WORK

The Experiment was carried out on a water cooled direct injection diesel engine. Eddy current dynamometer is used for loading i.e., electrical loading. The engine specifications are given in Table 1.

Line diagram of 4-Stroke Water cooled direct injection diesel engine:

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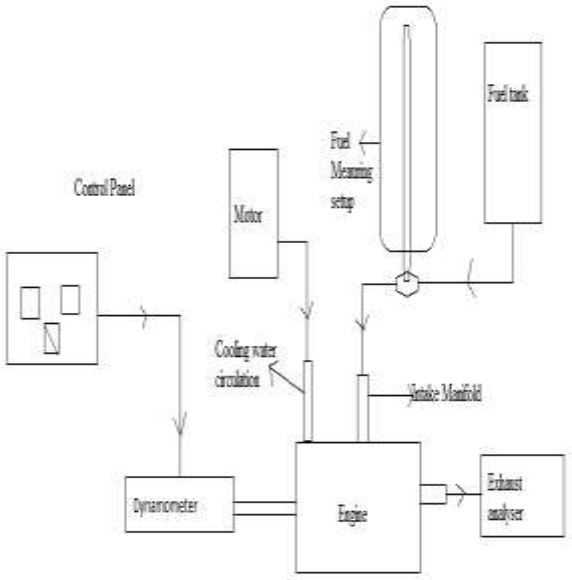

Figure 2: DIESEL ENGINE

Table 2: Test Engine Specifications

Particulates	Specifications
Model	AVI
Make	Kirloskar Oil Engine Ltd.
Arrangement of cylinders	Vertical
Lubricant	SAE 20/SAE40
No of cylinders	1
Bore	85mm
Stroke length	110mm
Rated speed	1500 rpm
Rated power	3.68 Kw (5HP)
Compression ratio	17.5:1
Starting	Hand start with crank handling
Fuel oil	High Speed Diesel (HSD)
Type of cooling	Water cooled

First of all the blends of biodiesel BD10, BD20, BD30, BD40 are prepared by mixing 90%, 80%, 70%, 60% of diesel with 10%, 20%, 30%, 40% of mustard biodiesel on volume basis.

Emulsification Process: Required volume of Biodiesel blends and water are taken in volume percentages in a container respectively, Then surfactants are added in order to make the emulsion stable. Then container is placed under the mechanical agitator for about 30-45 minutes. The solution is emulsified. Here EB10, EB20, EB30, EB40 are being used as emulsified fuels. The quantities of surfactants TWEEN®20 and TWEEN®80 are taken as 1:1 on volume basis.

NOMENCLATURE

EB10 (BD10+10%H_20+2% S)

EB20 (BD20+10%H_20+2% S)

EB30 (BD30+10%H_20+2% S)

EB40 (B410+10%H_20+2% S)

S = Surfactants

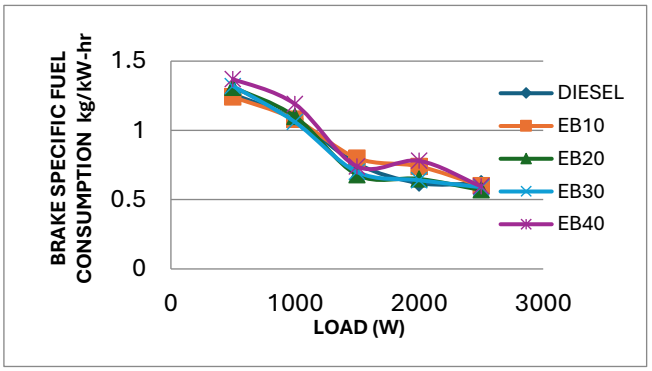

Fig.4.1 Variation of Brake specific fuel consumption with Load

The variation in the brake specific fuel consumption (BSFC) with respect to load is shown in the Fig.4.1. From fig.4.1 it can be clearly seen that the BSFC for different biodiesel blends is lower than the standard engine with diesel fuel at full load. Use of water increases the combustion efficiency of the engine by keeping the temperature in the working range .As keeping the percentage of water in the emulsion as constant and varying the amount of biodiesel. The amount of diesel is replaced by an equal amount of water. This means that less diesel fuel is actually contained in unit volume of the emulsion. So, due to the percentage of water in the emulsion decrease the BSFC.

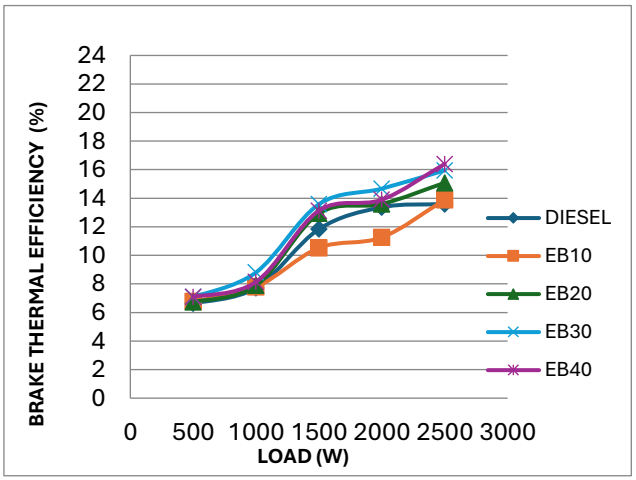

Fig.4.2 Variation of Brake Thermal Efficiency with Load

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The variation of brake thermal efficiency with respect to load for emulsified mustard blends and diesel are shown in Fig.4.2. It can be observed from the results that emulsified mustard blends improve the thermal efficiency when compared to diesel.The amount of water in the emulsion increases the brake thermal efficiency. The presence of water in the emulsion increases the expansion work and reduces the compression work resulting increased net work done during the cycle. The expansion of water vapour offers additional force on the top of the piston which increases the torque produced during the cycle. In the biodiesel emulsion, the diesel quantity is replaced by equal amount of water per unit volume. So, the increase in net work done and decrease in fuel consumption causes higher brake thermal efficiency.

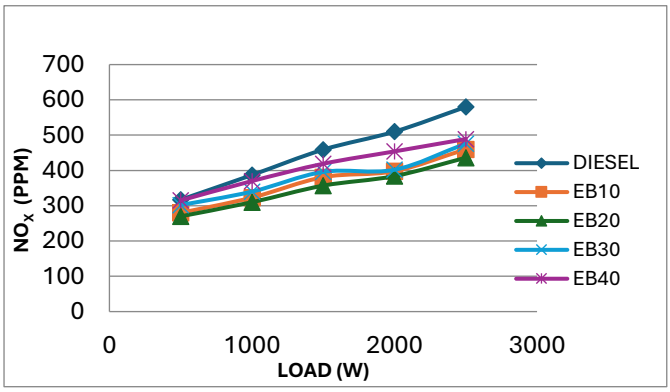

Fig.4.3 Variation of NO_X with Load

The variation of Nitrogen oxides with respect to load is shown in fig 4.3. The formation of nitrogen oxide emissions depends on the heat transfer rate and evaporation rate of the fuel. With increase in load NO_X emission increases for diesel as well as other fuels. It has been observed that using diesel water emulsion as fuel greatly reduces the NO_X 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 mono atomic nitrogen decreases thereby reducing the chances of formation of NO_x.

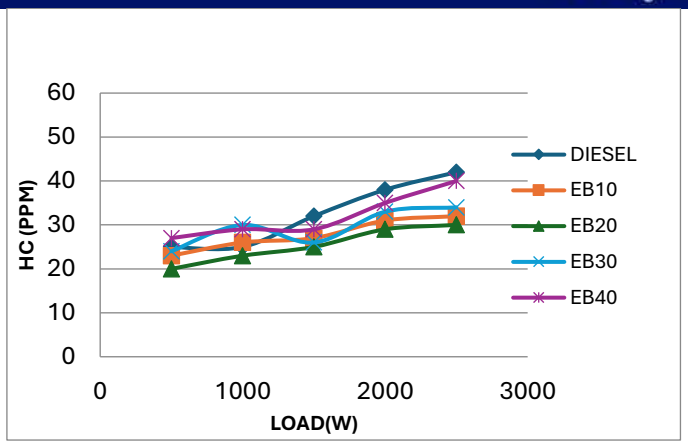

Fig.4.4 Variation of HC with Load

The variation of hydrocarbons with respect to load is shown in Fig.4.4. From the results, it can be noticed that the concentration of hydrocarbon in emulsified mustard biodiesel blends is slightly lower than diesel. The micro-explosion phenomenon in emulsified fuel due to the volatility differences between water and diesel fuel causes violent disintegration of fine droplets and consequently enhances the fuel-air mixing in the combustion chamber helps in reducing the formation HC.

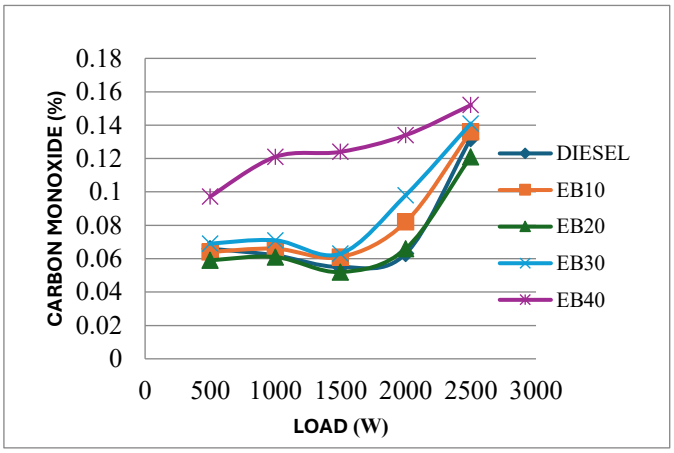

Fig.4.5 Variation of CO with Load

The variation of carbon monoxide with respect to load is shown in figure 4.5. CO emissions are increased for all emulsified biodiesel blends when compared with diesel at full load condition except for blend EB20 .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 [9]. It has been observed that emission of CO increasesbecause volume of water in the emulsion. This happens because due to the water content the temperature inside the cylinder decreases slowing down the combustion of carbon, as a result of which incomplete combustion occurs [10].

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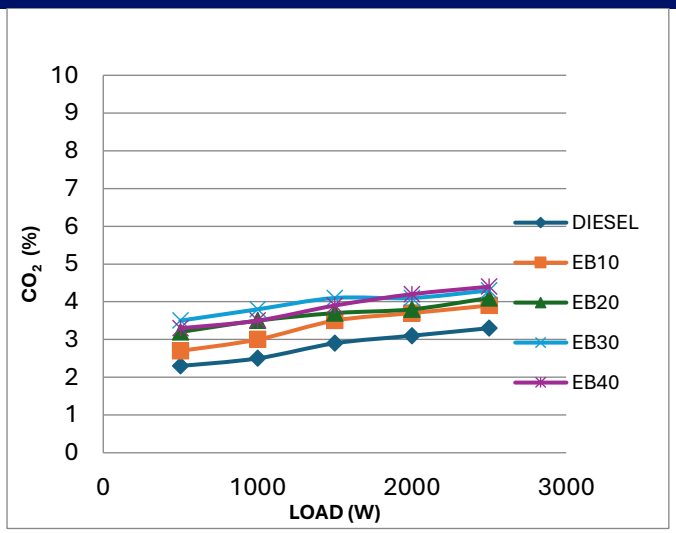

Fig.4.6 Variation CO_2 with Load

The variation of carbon dioxide emissions with respect to load is shown in Fig 4.6. From the results, it is observed that the amount of CO_2 produced while using emulsified mustard oil blends are higher than diesel at full load condition, this indicates the complete combustion of fuel. As a general rule, the higher the carbon dioxide reading, the more efficient the engine is operating [7].

The variation of smoke density with respect to load is shown in figure 4.7. In diesel engine smoke formation generally occurs in the fuel rich zone at high temperature, particularly within the core region of fuel spray. It can be shown that the smoke density of EB10, EB20, EB30, EB40 are lower by 25%, 22.1%, 18%, 31.7% and 27.8% respectively than that of diesel fuel at full load. The significant reduction in smoke emission may be due to the presence of oxygen in the emulsified fuel blends. Emulsified mustard biodiesel experience more reduction in smoke density [8].

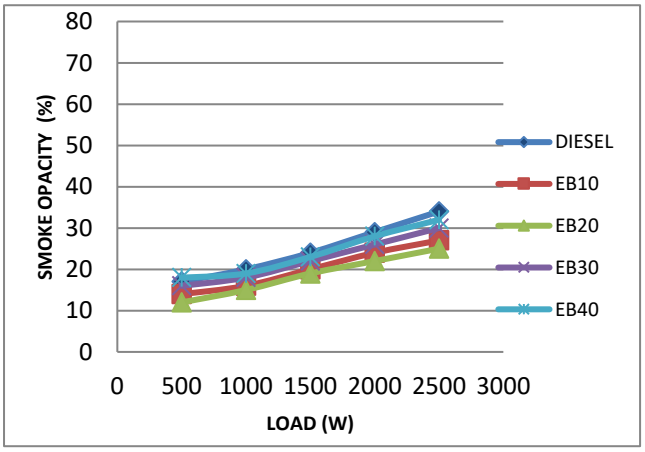

Fig.4.7 variation of smoke opacity with load

IV. CONCLUSION

The results of this study may be summarized as follows.

Thermal efficiency of the engine is high with emulsified mustard biodiesel blends when compared with diesel. The presence of water in the emulsion increases the expansion work and reduces the compression work resulting increased net workdone causing an increase in efficiency.

It is observed that reduction of BSFC for engine by using emulsified mustard biodiesel blends as compared to diesel fuel.NO_X emissions are brought by 30-40% by using emulsified blends.

Carbon dioxide emissions of emulsified blends increaseshigh compared to diesel. This is due to the fact that complete combustion of fuel in the combustion chamber.

The concentration of hydro carbon emissions is less for emulsified blends when compared to diesel.

The CO emissions are high for emulsified blends when compared with diesel.

Performance and Emission analysis of diesel engine is compared with emulsified mustard bio diesel and pure bio diesel in this experimental investigation. From this investigation it is observed that blend EB20 gives better performance and emission results when compared to all the blends and diesel.

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