Research Study on Performance and Emission Characteristics of Oxygen Enriched Combustion of Water Emulsified Palm Biodiesel

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Abstract— Environmental degradation is the major dilemma of present time. The depletion of environment is mainly due to pollutants emitting from exhaust of motor vehicle. Such pollutants are CO, NO_x, CO_2, HC, soot emission etc. Present research work is to controlling the amount of these pollutants from emission of single cylinder four stroke water cooled diesel engine and to find performance of diesel engine by combine effect of oxygen enrichment and water emulsification of fuel. The fuel used for research is diesel and diesel – palm biodiesel blend (PB10). Emulsification of diesel – palm biodiesel blend (PB10) are made with water concentration 5% and 10 % respectively and oxygen enrichment with 9 – 10% are used for present research work. The experimental results show that there are reduction in emission due to combine effect of oxygen enrichment and water emulsification. OED and diesel has a lower SFC than and all other blends. OEWIP 10% has lower emission of NOx while, OED and OEPB10 has higher value of NOx. OEWIP 5% and OED has lower emission of HC while, WIP 10% has a higher emission of HC.OEWIP 5% and OEPB10 has a lower CO2 than all other blends. Emission of CO is lower for WIP 5% and OEWIP 5% than other blends.

Key words: OEPB10, OEWIP, Palm Biodiesel Blend

I. INTRODUCTION

The burning of fossil fuels increases as economies grow and the adverse effect of such fuels has prompted a search for fuel alternatives worldwide. Thus, Bio-fuels have become as a substitute for fuel oil, especially for oil-importing countries. The most important advantage of these Bio-fuels is that they are renewable, and are being seen as sustainable sources of energy. Some Researches showed that bio-fuels helps in reducing environmental degradation by reducing harmful pollutants and addressing the problem of the increase in import cost of fuel oil. Diesel engine emits hydrocarbon (HC), oxides of nitrogen, carbon monoxide, soot, and particular matter. All those pollutants have very harmful effect on pollution as well as on human health. Thus, various researches had been done to minimize the amounts of pollutants and to improve performance of IC engine. Therefore it's required to find alternative of this conventional fuels. One of the alternatives of diesel is to use emulsified bio-diesel with oxygen enrichment. Since 1960s, the researches on intake oxygen-enriched combustion (OES) of internal combustion engine have begun, and the intent was to reduce engine-out emissions. Previous preliminary experimental studies showed that oxygen-enriched intake to improve oxygen concentration of combustion chamber by maintaining diesel injection law unchanged, which can accelerate the burning rate, improve combustion temperature, and enhance thermal efficiency to some extent. Diesel fuel in cylinder can also be burnt more thoroughly. Content of CO, HC and PM emissions can be reduced simultaneously because of more complete oxygen-enriched combustion. The power output can also be enhanced by increasing the intake oxygen concentration and fuel mass injected per cycle.

II. MATERIAL PREPARATION

The fuel used for research work is diesel and Palm biodiesel blend (PB10). Emulsification and oxygen enrichment of fuel is prepared for research. Emulsification of PB10 is made with water concentration 5% and 10%. Then oxygen enrichment study made on this emulsified PB10 fuel. Since both the liquids are immiscible in nature. Thus, surfactants are added to the mixture of water and palm bio – diesel to make mixture more stable. Surfactants TWEEN 80 and SPAN 80 are added to mixture.

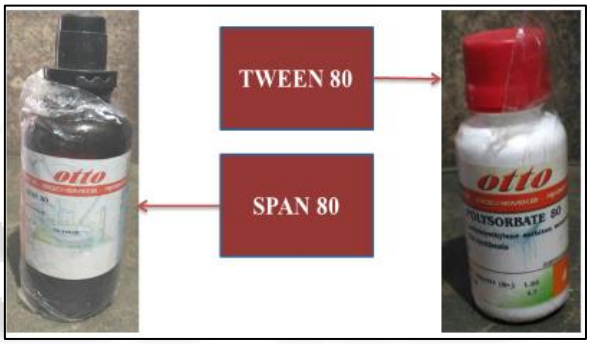

Fig. 1: Surfactants SPAN 80 and TWEEN 80

Emulsified fuel from PB10 and Water are prepared on error and trail method. Stable emulsion are obtain by adding Surfactants span 80 to PB10 and Tween 80 to water by 1% of each for 1000 ml solution.

Proportion of emulsifying agents in each blend of WIP 5% and WIP 10% are shown in table 1.

Water quantity	5% (ml)	10% (ml)
PB10	930	880
Water	50	100
Span 80	10	10
Tween 80	10	10

Table 1: Proportion of surfactants and water content

Thus emulsified fuel is shown in figure 2

Fig. 2: Emulsified Fuels

Fig. 3: Unstable emulsification

Here, figure 3 shows unstable emulsified fuel. This is not making homogenous mixture. Thus emulsification of diesel – pal biodiesel blend are prepared with water concentration 5% and 10% respectively, thus fuel WIP 5% and WIP 10% are prepared. Which are studied under various load operation to find performance and emission characteristics of fuel.

These emulsified fuel than study under oxygen enrichment. The oxygen cylinder is connected to the intake of research engine. Oxygen proportion feed with intake air is 9-10%.

III. EXPERIMENTAL SETUP

The experiment was carried out on single cylinder four stroke variable compression ration diesel engine. The main aim of the experimentation is to check performance and emission characteristics of CI engine fuelled with water emulsified palm oil biodiesel blend. The experimental work under this project consists of two phases; initial phase is experimental work to find out the effect of different engine loads and blend ration on engine performance and emission of IC Engine. In second phase, optimizing work for the optimum water emulsified palm oil biodiesel blend. Initial experimental work includes preparation of experimental setup, various water emulsified palm oil biodiesel blends and measurement of various engine parameters and emission parameters by running the engine on different Engine loads.

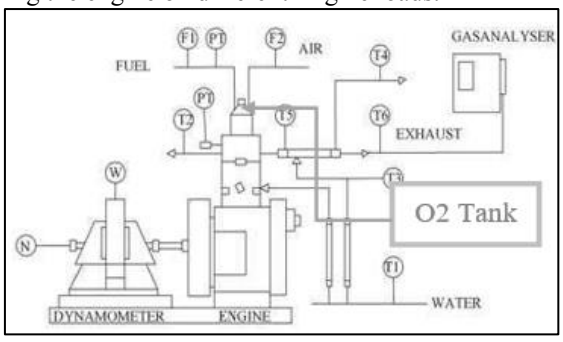

Fig. 4: Schematic diagram of experimental setup

Schematic diagram of experimental setup is shown in figure 4. The experimental setup comprises of single cylinder, four stroke, Multi-fuel, research engine. This engine is connected to eddy-current type dynamometer for loading. The mode of operation in this engine can be changed from diesel to Petrol or from Petrol to Diesel as required with some needed changes. In both operation modes the compression ratio can be changed without stopping the engine and no other changes needed for the geometry of combustion chamber by specially designed tilting cylinder block arrangement. Different other instruments are provided to interface are airflow meter, fuel flow meter, temperatures and load measurement devices. For cooling water and calorimeter water flow measurement Rota meter is provided. For auto start of engine a battery, starter and battery charger is provided. Analysis software Engine-soft is provided for on line performance evaluation and lab view based Engine Performance. For oxygen enrichment, the oxygen cylinder is connected to the engine inlet manifold. The test engine used in this experiment is as shown in figure 5.

Fig. 5: Experimental setup of C I engine

The specifications of the single cylinder four stroke C I engine used in this experiment is as shown in table 2.

Engine manufacturer	Apex Innovations (Research Engine test set up)
Software	Engine soft Engine performance analysis software
Engine type	Single cylinder four stroke multi fuel research engine
No. of cylinder	1
Type of cooling	Water cooled
Rated power	3.5 kW @ 1500 rpm
Cylinder diameter	87.5 mm
Orifice diameter	20 mm
Stroke length	110 mm
Connecting rod length	234 mm
Dynamometer	Type: eddy current, water cooled, with loading unit

Table 2: Engine setup specifications

Also, the level of pollutants in the exhaust of the diesel engine is being measured with the help of Exhaust gas analyzer. The Exhaust gas analyzer used is as shown in figure 6. Its measure proportion of exhaust from diesel engine in ppm. Exhaust gas analyzer is used in various governments authorized test centers. Here, we used a five gas analyzer for measuring of CO, CO_2, NO_X, and HC Emissions.

Fig. 6: Exhaust Gas Analyser

IV. PERFORMANCE ANALYSIS

This section consist of comparison of performance parameters for diesel, diesel – palm biodiesel blend, water emulsified diesel – palm biodiesel blend and oxygen enriched water emulsified diesel – palm biodiesel blend. Performance parameters which are comparing are specific fuel consumption (SFC), break thermal efficiency (BTHE) and fuel consumption

A. Load Vs specific fuel consumption (SFC)

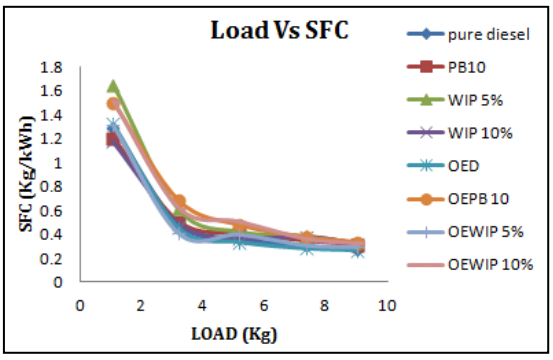

Fig. 7: Load Vs SFC

Figure 7 shows graphical representation of Load Vs SFC. SFC is not reliable because different fuels are blended together has a different calorific values and different densities. It's concluded from above figure 7.1 that OED has a lower SFC than diesel and all other blends under consideration. SFC is very nearer from diesel.

B. Load Vs BTHE

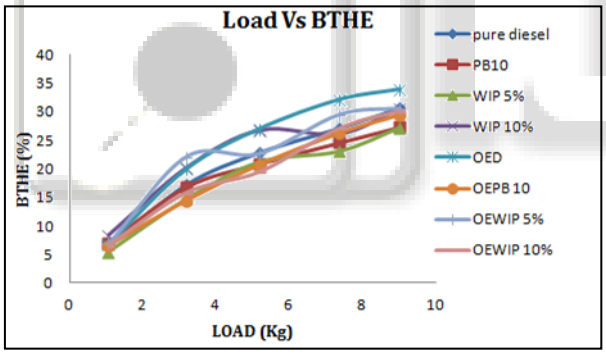

Fig. 8: Load Vs BTHE

Figure 8 shows graphical representation of Load Vs BTHE. As load increases, break thermal efficiency is increases. Best result is obtained with OED. And lower with WIP 5%.

V. EMISSION ANALYSIS

A. Load Vs NO_x

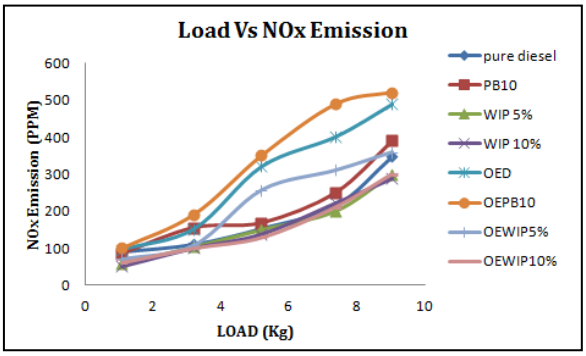

Fig. 9: Load Vs NO_x

Figure 9 shows the comparison of oxides of nitrogen (NO_x) emission at different load for diesel, blends of diesel with palm biodiesel, water emulsified diesel - palm biodiesel blend and oxygen enriched water emulsified diesel - palm biodiesel blend. As show in figure 7.4 emission of NOx increase as the load increase. It shows that higher NO_x is produce with oxygen enrichment. OED and OEPB10 emit higher NO_x. While, emulsification of diesel - palm biodiesel blend produce comparatively lower NO_x emission than diesel. And due to combined effect of oxygen enrichment and water emulsification OEWIP 10% emits lowest NOx.

B. Load Vs HC Emission

Figure 10 shows the comparison of HC emission at different load for various blends. As shows in above figure 7.5, emission of HC increase as load is increase. It shows emulsification of diesel - palm biodiesel blend emits higher HC. While, oxygen enrichment of emulsified diesel - palm biodiesel blend reduces emission of HC. OEWIP 5% and OED have a lower emission of hydrocarbon comparison to diesel, while WIP 10% have a higher HC emission.

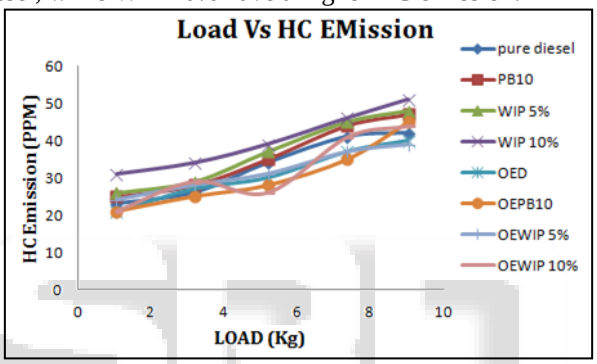

Fig. 10: Load Vs HC

C. Load Vs CO_2 Emission

Figure 11 shows the comparison of CO_2 emission at different load for various blends. As shows in figure 7.6, emission of CO_2 increase gradually with increase load. Diesel and OED emit higher CO_2 than all other blends under consideration. While other blends has comparatively lower CO_2 emission than diesel fuel. OEPB10 and OEWIP 5% have a lower CO_2 emission. Combined effect of oxygen enrichment and water emulsification of palm biodiesel produce comparatively lower CO_2 emission than only water Emulsified palm biodiesel; while Diesel and Oxygen enriched Diesel have a comparatively higher CO_2 emission.

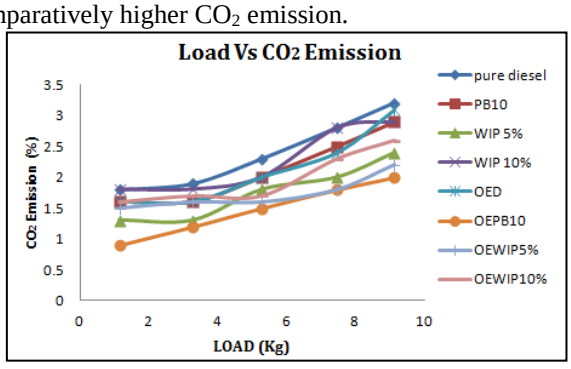

Fig. 11: Load Vs CO_2

D. Load Vs CO Emission

Figure 12 shows the comparison of CO emission at different load for various blends. Figure 7.7 shows that CO emission

decreases as the load increase. Here, oxygen enriched diesel (OED) emits higher CO at higher load while at lower load OEPB10 blend emits higher CO. Lower Emission of CO is obtained with WIP 5% and OEWIP %5. Thus combined effect of oxygen enriched combustion and emulsification of diesel - palm biodiesel blend can effectively reduce CO at higher load in comparison to diesel.

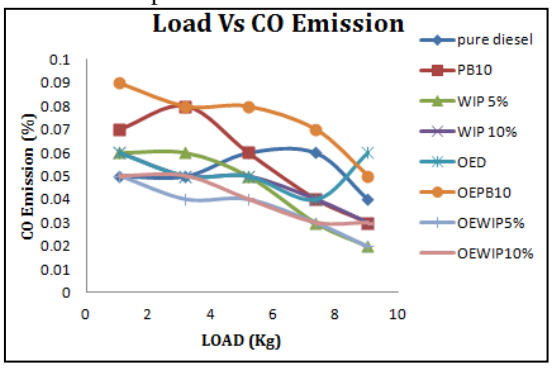

Fig. 12: Load Vs CO

VI. Conclusion

Oxygen enrichment and emulsification both method of reducing exhaust emission from the C.I engine fuelled with blend of diesel and diesel – palm biodiesel are used in present research work and combine effect of both method is study with various load operation. It's concluded from present research work that emulsification of blend PB10 can effectively reduce the exhaust emission of C.I engine. Few aspects that are concluded from present research work are as follow.

- Emulsification of PB10 effectively reduces exhaust emission from conventional diesel engine.
- Oxygen enrichment increase the NO_x and PM and reduce HC and CO due to complete combustion of fuel, thus, alternative hardware may be provided to control NO_x.
- Feasibility to use oxygen enrichment is difficult and is required more research to solve the problem of carry oxygen cylinder and to maintain oxygen intake proportion to inlet manifold.
- Emulsification of palm biodiesel make fuel more viscous than diesel therefore nozzle will prone to chock up and corrosion problem may be more due to water emulsification.
- Emission parameters are improved due to combined effect of water emulsification and oxygen enrichment.
- OED and diesel has a lower SFC than and all other blends.
- OEWIP 10% has lower emission of NO_x while, OED and OEPB10 has higher value of NO_x. OEWIP 5% and OED has lower emission of HC while, WIP 10% has a higher emission of HC
- OEWIP 5% and OEPB10 has a lower CO_2 than all other blends. Emission of CO is lower for WIP 5% and OEWIP 5% than other blends

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