PERFORMANCE EVALUATION ON SEMI - ADIABATIC DIESEL ENGINE USING WATER EMULSIFIED DIESEL AS FUEL

P.S.Bharadwaj [1], J.Paul Rufus Babu[2] , B.Madhubabu[4]

[1,2,3] *Lecturer, Department of Mechanical Engineering, JNTUACE, Anantapur, (India)*

ABSTRACT

The demand for petroleum products in India has been increasing at a very rapid rate. Amongst various options investigated for diesel fuel, biodiesel is one such initiative which is projected as an alternative to diesel fuel. The methyl ester of water emulsified diesel oil is one such an alternative fuel which can be used as substitute to conventional petro-diesel. The present work involves experimental investigation on the use of water emulsified diesel as fuel in conventional diesel engine and semi-adiabatic diesel engine. The project aims at conducting analysis of diesel with water emulsified diesel blends (10%, 20%, 30%) in conventional engine and semi-adiabatic engine. The engine was made semi adiabatic by coating the piston crown with nickel chromium coating.

Keywords: Coated Piston, Diesel Engine, Performance, Water Emulsified Diesel.

1. INTRODUCTION

In this modern world of industries and technology the diesel engine plays a major role in various fields. It may be transportation (or) production e.t.c., with the increase of various applications to the diesel resources effects on the environment leading to effect like green house. Higher fuel efficiency in the diesel engine is achieved due to the high compression ratios along with relatively high oxygen concentration I the combustion chamber. However, these same factors results in high emission in diesel engine. The stringent emission norms have been an important driving force to develop the internal combustion engines more environment friendly. The main pollutants from diesel engines are Carbon Monoxide and Hydro Carbons

This recommends the intensive studies on the use of alternative fuels especially renewable ones like vegetable oils and alcohol’s. The use of vegetable oils as an alternative fuel for diesel engine is not a new concept. Infact early engines were demonstrated with vegetable oil. In a developing country like India where mass transportation plays an important role, the suitability of alternate fuels for a diesel fuel engine application has to be thoroughly investigated. Vegetable oils plays a prominent role in substituting diesel, since they are renewable and are easily produced in rural areas.

The inventor of diesel engine, Rudolph diesel confidently predicted that plant oil would be widely used to operate his engine. Rudolph diesel used peanut oil as fuel in one of his engines at the Paris exposition of 1900. But due to its high price compared readily available petroleum products, the use of vegetable oil based fuels was not explored. But the fuel crisis of 1970"s and 1980"s focused the attention on the desirability to develop alternative fuels.

It is believed that vegetable oils can be used diesel engines as an alternative to diesel with minimal processing and preparation. However it is observed by many researchers that while the diesel engines operated satisfactorily on raw vegetable oils. Combustion residues and deposits would quickly cause problems with fuel injectors, Piston rings and oil stability. Further their higher viscosity and higher pour point compared to diesel, could affect the engine operation in very cold climatic conditions. The vegetable oils are more prone to oxidation and polymerization than diesel and consequently the engine oil becomes too thick.

Generally, the vegetable oils have approximately 13% less energy than that of diesel fuel. The loss of energy caused by the oxygen content of vegetable oils is approximately 10%. They have higher specific gravity which is approximately 0.88 compared to that of diesel. Whose specific gravity is approximately 0.82. Hence the vegetable oils regain some of the loss in energy on a mass basis for an overall impact of approximately 7% loss in energy per unit volume. Hence the use of vegetable oils in diesel engine should experience a loss of fuel economy of about 7% on an average.

The viscosity vegetable oils tend to alter the injector spray pattern inside the engine causing the fuel impingement on the piston on the other combustion chamber surfaces. This leads the formation of carbon deposits in the engine eventually results in the problems such as stuck piston rings with subsequent engine failure which would not occur using diesel fuel.

The other important hurdle, for the use of vegetable oils in diesel engines, is to control the exhaust emissions, which is usually high in vegetable oil operation. The main reason for the very high emissions of the vegetable oil is the non optimized injection system for the particular vegetable oil, whose physical properties vary to a greater extent when compared with diesel fuel.

The in efficiency of the non optimized injection system can be compensated by hotter combustion chamber which assists (vegetable oils) spray atomization. Hence the vegetable oil operation of the conventional engines is more efficient with low emissions compared with vegetable oil operation of the conventional engines. Because of the oxygen content of the vegetable oils, CO emissions are similar to the diesel operation or even lower in some oils. The smoke and un-burned fuel emission levels depend on the fuel spray. Characteristics and hence the conventional engine configuration reduces them to a greater extent.

Ultimately the disadvantages of vegetable oils, which are the causes for poor performance and heavy smoke can be overcome by the use of vegetable oils in the conventional engine since the gas temperatures are higher. Hence in the resent work KARANJA OIL has been tested as fuel in the conventional engine and semi adiabatic engine.

II SEMI-ADIABATIC ENGINE

The trend of converting existing engine into Semi-adiabatic diesel engines is to retain most of the heat within and then convert it into useful work. It is believed that through better design of the injection system significant improvements in efficiency, speed and smoothness of operation can be achieved. Further, developments in the diesel engine appear to be in the direction of detailed investigation of the losses in the diesel engine and their control.

In the present day diesel engine, out of the total heat energy supplied, only about one third of supplied energy is converted to useful work at the output shaft, one third is lost through exhaust gases and the rest carried away by the cooling water. Reducing the heat transfer to the coolant increases the exhaust energy. One method of obtaining the above condition is to thermally insulate the combustion chamber converting it into an adiabatic engine. This method insulates the combustion chamber, using high temperature materials, which allow "hot" operation near to adiabatic conditions. The hot or insulated high temperature components include piston, cylinder head, valves, cylinder liner and exhaust ports.

Further, the efficient combustion process in Semi-Adiabatic engine will allow multi fuel capability. The compact size and high power/weight ratio of the semi - adiabatic engine will significantly reduce the size and weight of the vehicle. In view of the above, the present investigation aims at the development of a Semi-Adiabatic engine with locally available technologies. Attempts were also made to solve the typical problems associated with Semi- Adiabatic engine. Due consideration has been given for the utilization of the energy from the high temperature exhaust gases of the semi - adiabatic engine.

Semi-Adiabatic engine is made with 50 microns of NiCrAl bond coat is used and the experiments are conducted using Water emulsified diesel biodiesel. The idea behind this is that for Semi-Adiabatic engine at 50 microns of NiCrAl bond coat creates a higher combustion chamber temperature that may lead to the improvement in the combustion characteristics of biodiesel, brake thermal efficiency of the engine and reduction in the exhaust emissions. The present work aims to develop a Semi-Adiabatic engine using different techniques and improve its performance, fuel economy, multi-fuel capability, combustion characteristics by reducing frictional power, increasing volumetric efficiency etc.

III EXPERIMENTAL INVESTIGATION

The experiments were conducted by considering various parameters. The tests were conducted for Water emulsified diesel biodiesel with Diesel at different proportions (10%, 20% and 30%) for both conventional engine and coated piston engine. The tests were conducted from no load to maximum load conditions. The readings such as time taken to consume 20cc of fuel consumption, speed of the engine, temperatures, etc, were noted. The observations were recorded in tabular column and calculations are made using appropriate equations.

The experiments were conducted on a single cylinder Alamgir four stroke diesel engine. The general specifications of the engine are given in Table-1. By taking the engine performance and plot the graphs

"ALAMGIR" engines for generating sets are fuel efficient, with the lube oil consumption less than 1% of S.C.F. lowest among the comparable brands. They are equipped with heavy flywheels incorporating 4% governing on the fuel injection equipment. This complete avoids voltage functions. In case of emergency, the unique overload stop feature safeguards equipments by shutting down the engine automatically

Table-1. Engine specifications

Item	Specifications
Engine power	6.6 kW
Cylinder bore	102 mm
Stroke length	110 mm
Connecting Rod Length	234 mm
Engine speed	1500 rpm
Compression ratio	17.5

Table 2: Properties of Diesel and Water emulsified diesel biodiesel

Properties	Diesel	Water emulsified diesel Biodiesel
Calorific Value (kJ/kg)	43000	59835.82
Density (kg/m3)	850	828
Flash point (°C)	40	175
Fire point (°C)	42	185

An exhaust gas analyze was used to measure CO, HC, CO2, O2, and NOx. The measuring range and resolution are given in Table-2.

The water emulsified diesel fuel was prepared by mixing 10%, 20% and 30% of distilled water with 90%, 80% and 70% of diesel by volume, respectively. Polysorbate 20 was used as surfactant to prepare emulsion. Polysorbate 20. (0.1%) is added with 100 ml and 200 ml distilled water and mixed with 900 ml and 800 ml diesel to prepare D10 and D20 emulsified diesel fuels, respectively. The mixer was stirred for 2-3 minutes in an electrically operated agitator. The experiments were performed at constant speed of 1500 rpm. The engine was loaded by electrical dynamometer.

Table 3. Exhaust gas analyzer specifications

Measuring item	Measuring method	Measuring Range	Resolution
CO	NDIR	0-9.99%	0.01%
HC	NDIR	0-5000ppm	1ppm

CO_2	NDIR	0-20%	0.10%
O_2	Electrochemical	0-25%	0.01%
NO_X	Electrochemical	0-5000ppm	1ppm

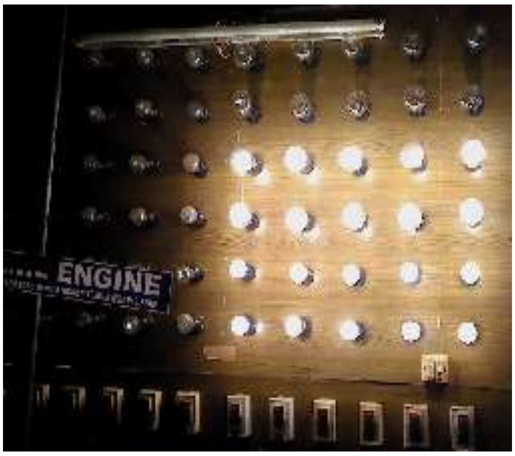

Fig 1: Alamgir Engine **Fig 2: Load Indicator**

IV RESULTS AND DISCUSSION

4.1 Indicated thermal efficiency

Indicated thermal efficiency indicates the output generated by an engine with respect to heat supplied in the form of fuel in modern engines an indicated thermal efficiency of 35%.

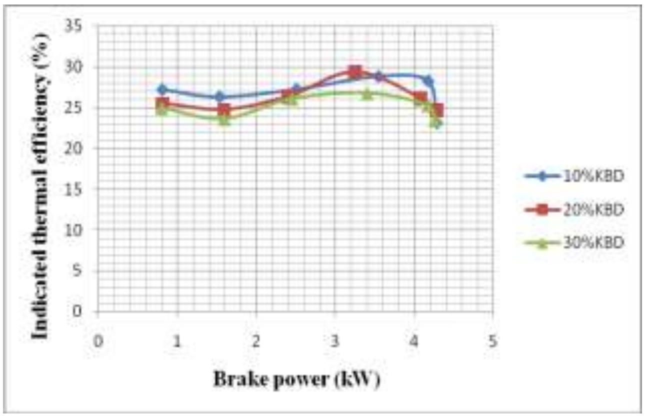

Fig1. Indicated Thermal Efficiency Vs Brake Power in conventional engine

It is observed that Indicated thermal efficiency increases as the load increases, and then decreases for all fuel samples tested. From the Fig. 2 it is also observed that maximum Indicated thermal efficiency of 32.96% is obtained at 20% Water emulsified diesel biodiesel blend with coated piston engine.. From the Fig. 1 it is observed that maximum Indicated thermal efficiency of 29.4% is obtained at 20% Water emulsified diesel biodiesel blend with conventional engine, which is less when compared to 32.96 % that other blends of Water emulsified diesel biodiesel.

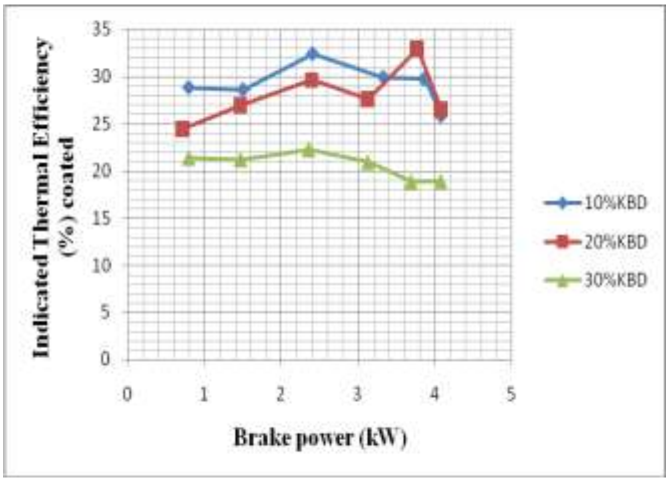

Fig2. Indicated Thermal Efficiency Vs Brake Power in semi-adiabatic engine

4.2 Brake Thermal Efficiency

Brake thermal efficiency indicates the ability of the combustion system to accept the experimental fuel, and provides the comparable means for assessing how efficiently the energy in the fuel was converted in to mechanical efficiency.Fig3. and Fig4. Shows the variation of brake thermal efficiency with brake power.

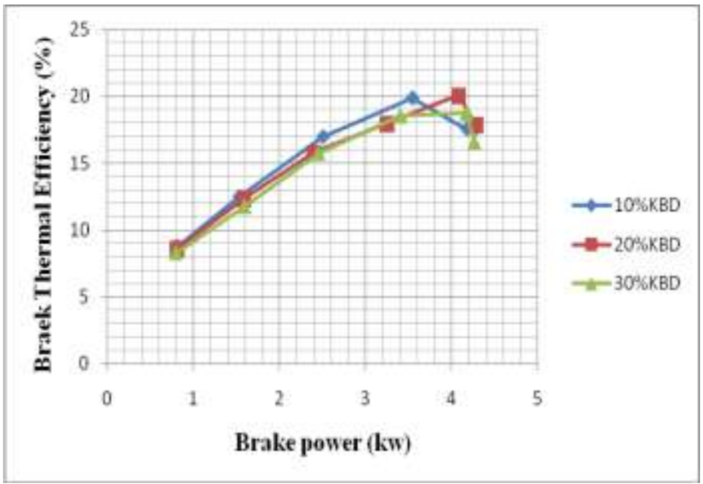

Fig3. Brake Thermal Efficiency Vs Brake Power in Conventional engine

It is observed that brake thermal efficiency increases as the load increases, and then decreases for all fuel samples tested. From the Fig. 3 it is also observed that maximum brake thermal efficiency of 20.08% is obtained at 20% Water emulsified diesel biodiesel blend.. From the Fig. 4 it is observed that maximum brake thermal efficiency of 20.28% is obtained at 20% Water emulsified diesel biodiesel blend, which is more when compared to 20.08% that other blends of Water emulsified diesel biodiesel.

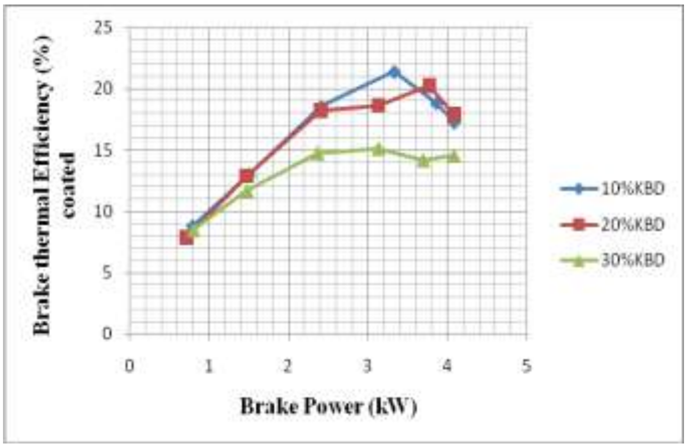

Fig4. Brake Thermal Efficiency Vs Brake Power in semi-adiabatic engine

The reason for increase in efficiency at blend of 20% Water emulsified diesel biodiesel may be the property of blend, probably the lower viscosity of biodiesel which helps in better atomization and effective utilization of air resulting in increased efficiency. The decrease in brake thermal efficiency for higher blends may be due to the lower heating value and higher viscosity of blends with a higher proportion of biodiesel.

4.3 Brake Specific Fuel Consumption

Fig. 5 and 6 shows the variation of brake specific fuel consumption for Water emulsified diesel biodiesel blends in conventional and semi adiabatic engine.. From the figure, it is observed that brake specific fuel consumption is less in semi-adiabatic engine when compared to conventional engine.

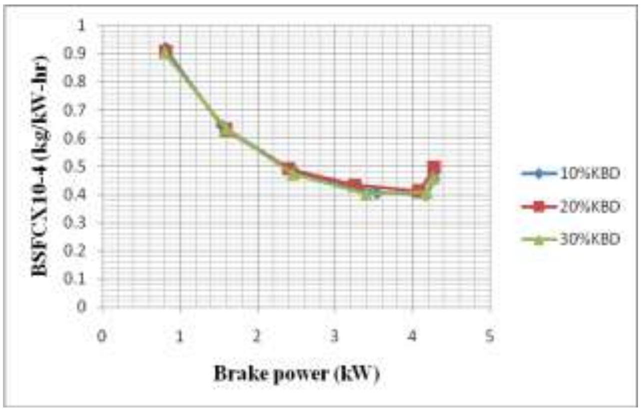

Fig5. Brake specific fuel consumption Vs Brake Power in conventional engine

It is also observed that the difference in percentage decrease in brake specific fuel consumption decreses with increase in percentage of Water emulsified diesel biodiesel in the blend. Also 20% Water emulsified diesel biodiesel blend with nickel chrome coated piston engine has minimum brake specific fuel consumption when compared to other blends of Water emulsified diesel biodiesel as shown in Fig. 5 and Fig. 6.

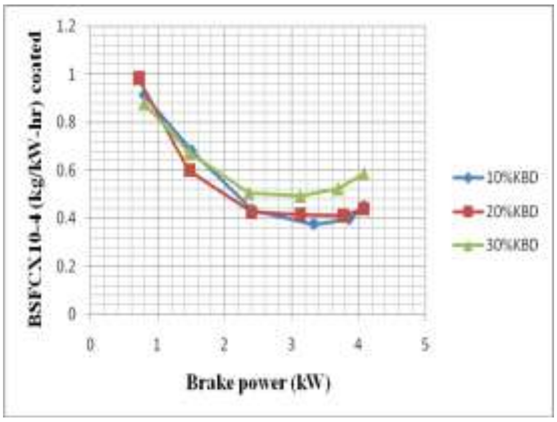

Fig6. Brake specific fuel consumption Vs Brake Power in semi-adiabatic engine

4.4 Exhaust Temperature

Fig. 7 and Fig. 8 show the variation of exhaust gas temperature with brake power for different blends of Water emulsified diesel biodiesel in conventional and semi-adiabatic engine respectively. The exhaust gas temperature increases with increase in load. The exhaust gas temperature is less at partial load for Water emulsified diesel biodiesel blend than pure diesel.

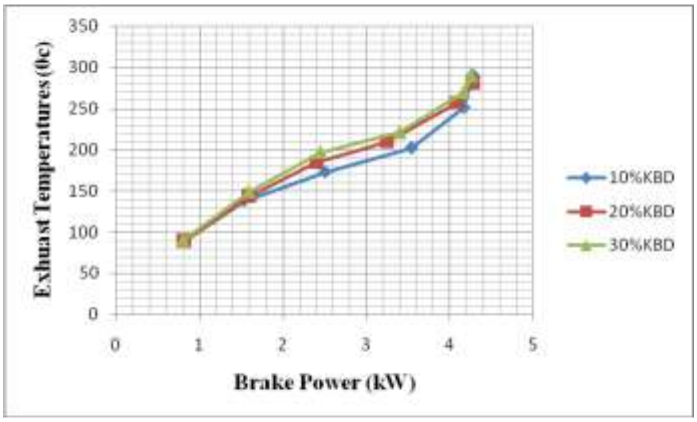

Fig7. Exhaust temperature Vs Brake Power in conventional engine

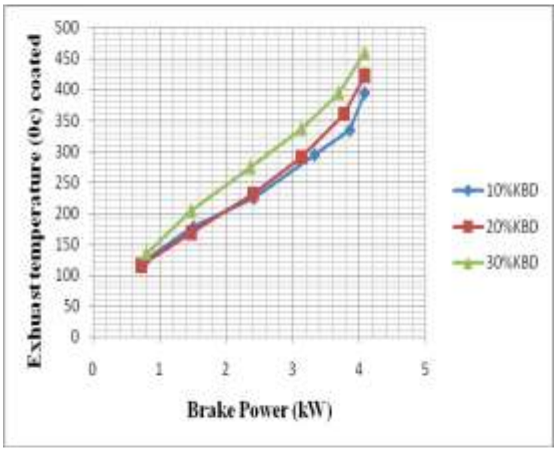

Fig8. Exhaust temperature Vs Brake Power in semi-adiabatic engine

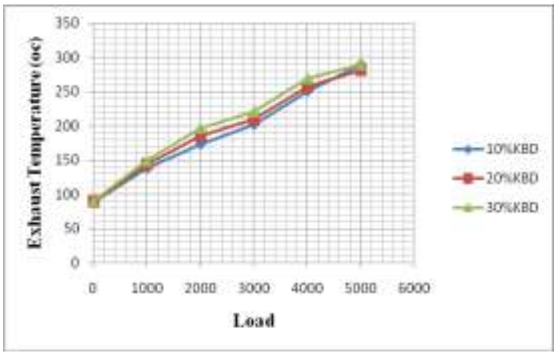

Fig9. Exhaust temperature Vs Load in conventional engine

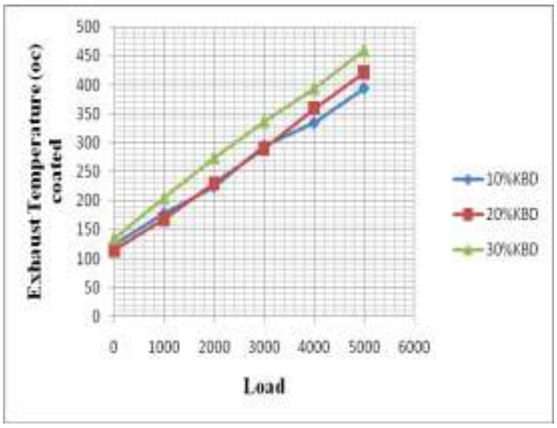

Fig10. Exhaust temperature Vs Load in semi-adiabatic engine

4.5 Brake Specific Fuel consumption with Load

Fig. 11 and 12 shows the variation of brake specific fuel consumption with load for Water emulsified diesel biodiesel blends in conventional and semi adiabatic engine. From the figure, it is observed that brake specific fuel consumption is less in semi-adiabatic engine when compared to conventional engine

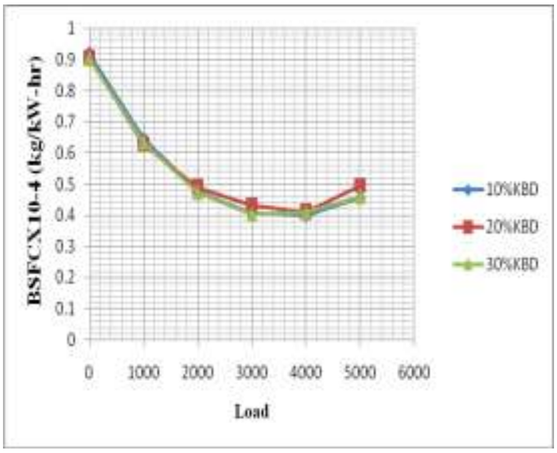

Fig11. Brake specific fuel consumption Vs Load in conventional engine

It is also observed that the difference in percentage decrease in brake specific fuel consumption increases with increase in percentage of Water emulsified diesel biodiesel in the blend. Also 20% Water emulsified diesel biodiesel blend has minimum brake specific fuel consumption when compared to other blends of Water emulsified diesel biodiesel as shown in Fig. 11 and Fig. 12.

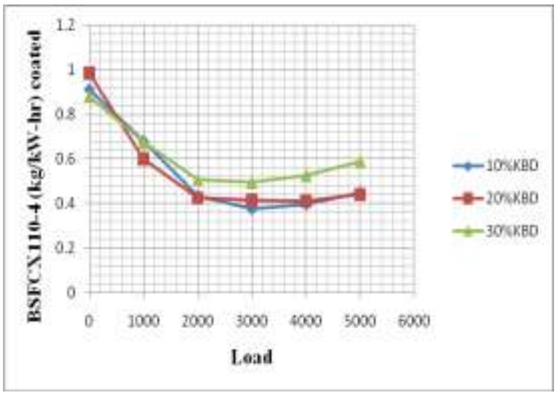

Fig12. Brake specific fuel consumption Vs Load in semi-adiabatic engine

4.6 Variation of mechanical efficiency with brake power

It can be observed from fig. 11, that the maximum mechanical efficiency at 20% water emulsified diesel blend full load is observed with piston coated with nickel chromium. At full load the mechanical efficiency with coated piston is found to be 73.12%, with while the same is 71.38% with conventional engine. The drop in mechanical efficiency with normal piston can be attributed to the higher coefficient of thermal expansion which results in increase friction at elevated temperatures and hence at high loads. By coating the piston with nickel chromium, the mechanical efficiency is found to be raised by 2.3%.

FIG13 and 14. Mechanical efficiency Vs Brake power in conventional and Semi-adiabatic engine

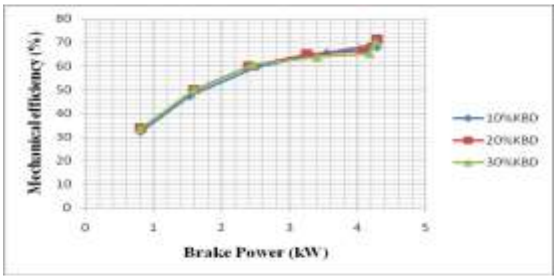

Fig13. Mechanical Efficiency Vs Load In Conventional Engine

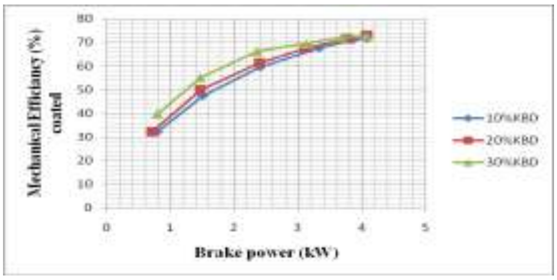

Fig14. Mechanical Efficiency Vs Brake Power In Semi-Adiabatic Engine

4.7 Variation of volumetric efficiency with brake power and load:- From fig. 15,16,17 and 18 it can be found that at 20% water emulsified diesel blend at full load the maximum volumetric efficiency is obtained with piston coated with nickel chromium while there is not much difference in volumetric efficiency obtained with conventional engine. At full load with coated engine the volumetric efficiencies are found to be 67.86% with 20% water emulsified diesel blend and with conventional engine it is found to be 64.14% at 20% water emulsified diesel blend .Thus volumetric efficiency is more with piston coated with nickel chromium at full load.

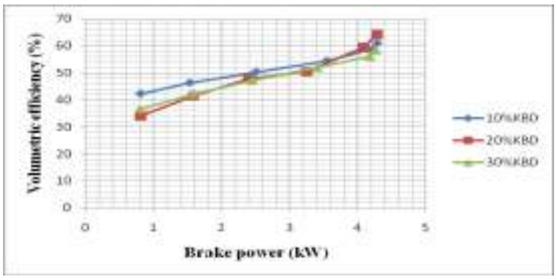

Fig15. Volumetric Efficiency Vs Brake Power In Conventional Engine

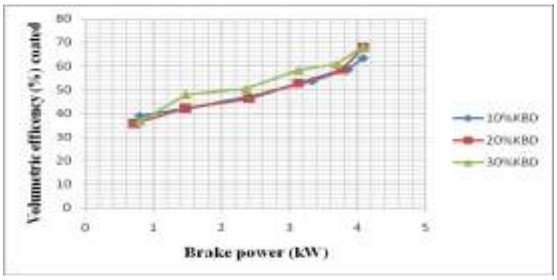

Fig16. Volumetric Efficiency Vs Brake Power In Semi-Adiabatic Engine

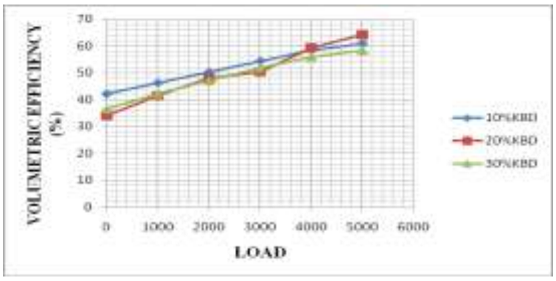

Fig17. Volumetric Efficiency Vs Load In Conventional Engine

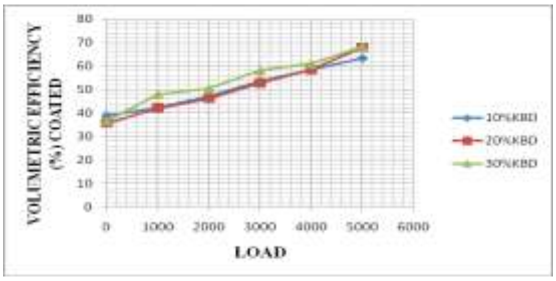

Fig18. Volumetric Efficiency Vs Load In Semi-Adiabatic Engine

4.8 Un-burnt Hydro Carbons

Fig. 19 shows the variation of hydrocarbon emission for different blends of Water emulsified diesel biodiesel at full load. It is observed that hydrocarbon emission reduces with conventional engine decreases at 20 % of klaranji biodiesel in blend. This may be due to lesser amount of diesel present in higher percentage blend. Lesser percentage of emission also indicates complete combustion.

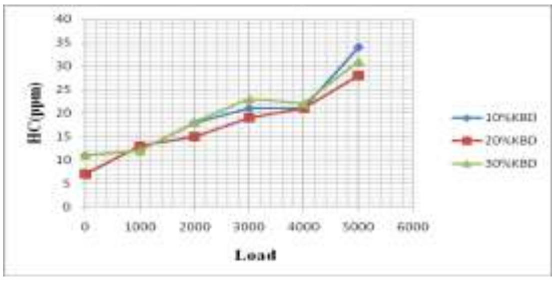

Fig19. HC Vs Load in conventional engine

Fig. 20 shows the variation of hydrocarbon emission for different blends of Water emulsified diesel biodiesel at full load. It is observed that hydrocarbon emission reduces more with coated engine at 20 % of klaranji biodiesel in blend. Lesser percentage of emission also indicates complete combustion.

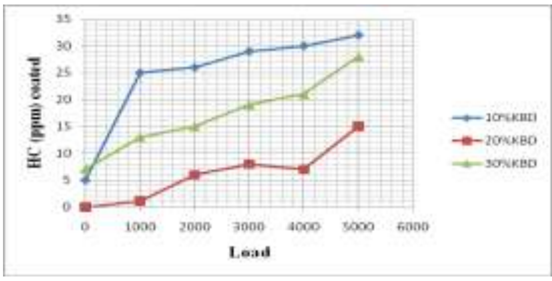

Fig20. HC Vs Load in coated engine

4.9 Carbon Monoxide

The variation of carbon monoxide emission in conventional engine at full load for blends of Water emulsified diesel biodiesel is as shown in Fig. 21. It is observed that emission of carbon monoxide decreases up to 20% blend of Water emulsified diesel biodiesel and increases for 10% and 30% blend. Lower percentage of carbon monoxide emission indicates complete combustion. Increase in carbon monoxide emission at 30% blend of Water emulsified diesel biodiesel may be due to the incomplete combustion.

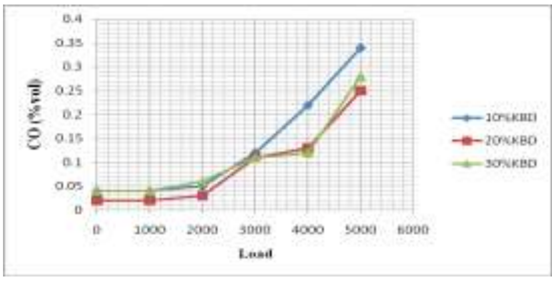

Fig21. CO Vs Load in conventional engine

The variation of carbon monoxide emission in coated engine at full load for blends of Water emulsified diesel biodiesel is as shown in Fig. 22. It is observed that emission of carbon monoxide decreases more than conventional engine up to 20% blend of Water emulsified diesel biodiesel and increases for 10% and 30% blend. Lower percentage of carbon monoxide emission indicates complete combustion. Increase in carbon monoxide emission at 30% blend of Water emulsified diesel biodiesel may be due to the incomplete combustion.

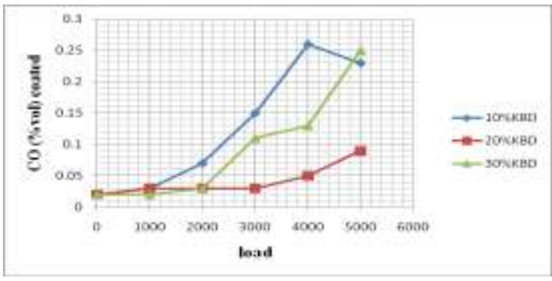

Fig22. CO Vs Load in semi-adiabatic engine

4.10 Carbon dioxide

The variation of carbon dioxide emission at full load for blends of Water emulsified diesel biodiesel in conventional engine is shown in Fig. 23. It is observed that percentage emission of carbon dioxide increases with increase in percentage of Water emulsified diesel biodiesel in blend.

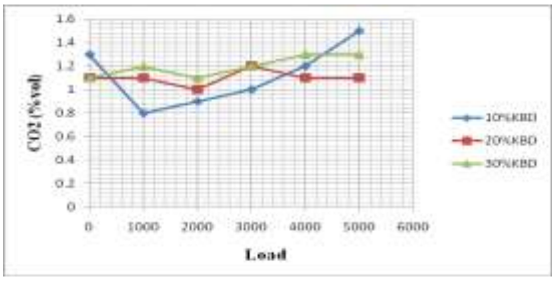

Fig23. CO2 Vs Load in conventional engine

The variation of carbon dioxide emission at full load for blends of Water emulsified diesel biodiesel in coated engine is shown in Fig. 24. It is observed that percentage emission of carbon dioxide decreased than in conventional engine.

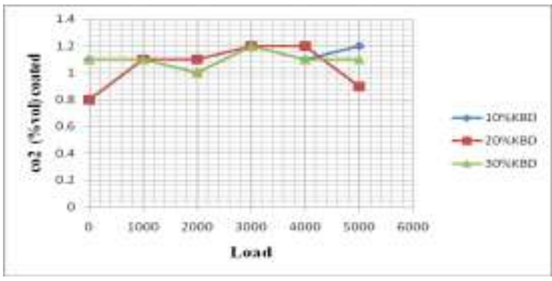

Fig24. CO_2 Vs Load in Semi-Adiabatic Engine

4.11 Oxygen percentage

The oxygen intake percentage is increased with increase in blend percentage in conventional engine and oxygen intake is more for 20% water emulsified diesel blend in coated engine. This shows that for semi adiabatic (coated) engine the oxygen intake increases the volumetric efficiency also increases which will ensure complete combustion.

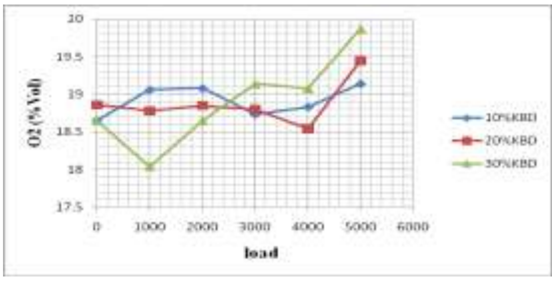

Fig25. O2 Vs Load In Conventional Engine

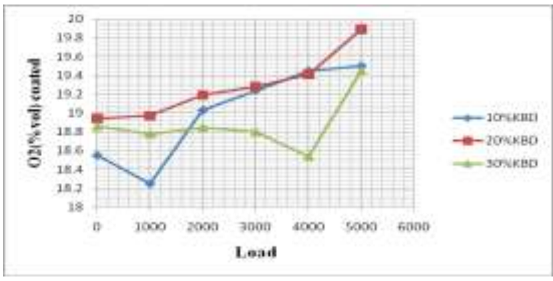

Fig26. O2 Vs Load In Semi-Adiabatic Engine

V CONCLUSION

It is observed that the semi-adiabatic engine works with improved performance while running with water emulsified diesel biodiesel blends compared to biodiesel blends of conventional engine. The blends of water emulsified diesel biodiesel with diesel fuel can therefore be used as an alternative fuel in existing diesel engine without modification of the basic engine. It is observed that amongst the different blends tested in the present work, 20% blend (diesel 80% & water emulsified diesel 20%) gives better performance. Also compared to other blends tested 20% blend gave the best results. It was also observed that the engine running with blends of water emulsified diesel biodiesel with semi-adiabatic engine gave better emission characteristics compared to water emulsified diesel biodiesel blends with conventional engine and also the mechanical efficiency is better with nickel chromium coated piston. The increase in mechanical efficiency is about 2,3% at full load. By using nickel chrome coated piston brake specific fuel consumption is reduced compare to conventional engine and is about 4.03%. Thus it can be concluded that semi- adiabatic engine will be used more efficiently for alternative fuels than conventional engine.

REFERENCES

1. Ekrem Buyukkaya, " Effects of thermal barrier coating on gas emissions and performance of a LHR engine with different injection timings and valve adjustments," Energy conversion and management 47(2006)1298-1310.

2. Internal Combustion Engines Fundamentals by "John.B.Heywood",McGrawHill(1988).
3. Thermal Engineering by R.K.Rajput
4. Internal combustion engines by V GANESAN
5. S.L. Ghodake, Prof.S.A.Pujari, "Bio diesel - Fuel for Automotives", Proceedings of the National Conference on Biofuels for IC engines, March 23-25, 2006, NIT, Surathkal, Karnataka-575 025
6. Ramesha D. K, G. Premakumara, Manjunath M. C, Honne Gowda "A study on effective use of Mahua methyl ester as alternative to diesel", Proceedings of 21st National conference on IC Engines & Combustion, Dec 10-12, pp 267-279, 2009.
7. P.K. Devan and N.V. Mahalakshmi, "A study of the performance, emission and combustion characteristics of a compression ignition engine using methyl ester of paradise oil–eucalyptus oil blends", Applied Energy, Volume 86, Issue 5, pp 675-680, May 2009.
8. Dr. Syamasundar Joshi, Dr. Shantha Joshi, "Simarouba Glauca (Paradise tree)", University of Agricultural Sciences, GKVK Bangalore.
9. Tilman Altenburg, Hildegard Dietz, Matthias Hahl, Nikos Nikolidakis, Christina Rosendahl, Kathrin Seelige, "Biodiesel policies for rural development in India- A report" German Development Institute, Bonn, May 2008.