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PERFORMANCE CHARACTERISTICS OF LOW HEAT REJECTION DIESEL ENGINE BY USING SORGHUM BASED BIODIESEL BLENDS

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ABSTRACT

The world's fossil fuel reserves are depleting rapidly. According to a survey 75% of the fossil fuel production will be decreased in coming eleven years and moreover a developing country like India invests heavily on the imports of fossil fuels. In internal combustion engines, approximately one third of the total fuel input energy is converted into useful work and two third is lost through exhaust gas and cooling system. And more over, diesel fueled vehicles discharge significant amount of pollutants like CO, HC, and NOx which are harmful for the environment.

Direct Injection (DI) diesel engines are becoming acceptable choice as a prime mover in many applications, it has become imperative to improve the power output and efficiency of the engine. For this purpose, several attempts are being done to improve the efficiency of DI diesel engine without sacrificing their fuel consumption advantages.

The main objective of the present work is to determine the performance characteristics and the effect of Magnesia Stabilized Zirconia (Mg-PSZ) on piston crown, cylinder head and compare them with conventional piston crown, cylinder head by using pure Diesel and various blends of Sorghum Bio-Diesel.

In the present work, Engine components such as piston crown and cylinder head are coated with Magnesia Stabilized Zirconia (Mg-PSZ) as Thermal Barrier coating. Plasma Spray coating technique has been used to coat the cylinder head and piston crown with Magnesia Stabilized Zirconia (Mg-PSZ) about 150 microns of thickness. This investigation is carried out on a single cylinder four stroke, air cooled DI Diesel engine at constant speed, varying load and constant injection pressure.

The performance parameters such as break power, specific fuel consumption and thermal efficiency are calculated based on experimental analysis of engine. Emissions such as Carbon Monoxide and unburned hydro carbon are measured. The data has been analyzed and the results are presented and discussed in this project.

Key words : Low heat rejection diesel engine, sorghum based biodiesel, Magnesia Stabilized Zirconia (Mg-PSZ) thermal barrier coating.

LITERATURE REVIEW

Mohamed Musthafa et al. (2011) In this study, for the first time fly ash was used as thermal barrier coating material for engine combustion chamber elements such as cylinder head, cylinder liner, valves, piston crown face to a thickness of 200 µm by using plasma spray coating method and experiments were carried out on LHR diesel engine fuelled by methyl ester of rice bran, Pongamia oil and its blend (20% by volume) with diesel. An increase in engine power and decrease in specific fuel consumption, as well as significant improvements in exhaust gas emissions were observed for all test fuel used in LHR engine when compared with that of the coated engine.

Park et al. (2007) examined the mechanical properties and micro structure evolution of the nanostructured WC-Co coatings fabricated by detonation gun spraying with post heat treatment process. Two different spray parameters were used to produce the work piece. The work were, then heat treated in an Arc environment at temperatures up to 900 0c. Using Vickers indentation testing, it was evident that the heat treatment up to 900 0c increased the micro hardness due to the presence of ŋcarbides. On the other hand, an increase in fracture toughness and wear resistance was achieved by heat treatment up to 800 0c, but it decreased after heat treatment at 900 0c. The decrease of fracture toughness and wear resistance at temperatures above 800 0c was due to the growth of carbides by several hundred nanometers.

Wang et al. (2007) examined the thermal shock behavior of Nano constructed and conventional Al2o3/13 wt. % Tio2 coatings applied by plasma spraying. Three types of coatings were produced. One produced from conventional commercially available powder and the other two types were derived from the Nano constructed agglomerated feed stock powders. Compared with the conventional coating the nano constructed coatings had improved bonding strength and micro hardness. In addition, thermal shock resistance was much higher in the nano constructed coatings, which was related to the unique microstructure consisting of three- dimensional net or skeleton- like structure. Lima and Marple (2008) examined the properties and effects of nano constructed yttria stabilized zirconia (YSZ) thermal barrier coatings engineered to counteract sintering effects. Since YSZ was used as a thermal barrier coating in the hot section of gas turbines, heat treatment of the work piece at 1400 0c for 1, 5 and 20 hours was carried out. It was noticed that the Nano constructed coating had bimodal distribution in the microstructure as a result of the previously molten and resolidified YSZ particles as well as the previously semi molten porous nano YSZ agglomerates embedded in the coating during the spray process. As a result of higher surface area in the nano constructed coatings and different sintering rates, it was found that the porosity level increased after 20 hours of heat treatment at 1400 0c to be 3.5 times the porosity level of the conventional coating. The different sintering rates and porosity level in the nano constructed coating prevented the increase of elastic modulus and thermal diffusivity over the time when subjected to elevated temperatures.

Rabizadeh et al. (2010) investigated the effects of heat treatment on the properties of Nickel Phosphorous (Ni-P) electro less nano coatings. When the heat treatment was carried at 200 0c, it was noticed that the hardness decreased as a result of hydrogen embrittlement and internal stress relieving. However, increasing the temperature of heat treatment to the range of 200 0c - 600 0c yielded significantly higher hardness values. Precipitation of Nickel phosphides (Ni3P) was anticipated to be the major factor for the increase in hardness. Furthermore, the corrosion resistance increased with heat treatment of the work piece at 6000c.

Yu et al. (2010) examined the thermal stability of the nano structured 13 wt.% Al2O3 8wt.% Y 2 O3 – Zr O2 thermal barrier coatings . The coatings were produced using air plasma spray onto stainless steel substrates. It was found that the increased annealing treatment time from 25 to 300 hrs resulted in increased ZrO2 grain size from 63 to 120 nm. Furthermore, the presence of nano – sized Al2O3 formed intragrannular structure that constrained the grain boundaries of ZrO2 and inhibited its growth. In addition, sintering at 1100 0c for 300 hours resulted in reduced porosity as a result of the grain growth and precipitation of Al2O3.

Kim et al. (2007) examined the effects of post-spraying heat treatment on wear resistance of WC-Co Nano composite coatings. The coatings were produced using the high velocity oxy-fuel thermal spray process. Consequently, heat treatmentwas carried out at temperatures in the range of 400 0c -1000 0c. Prior to heat treatment, XRD results indicated that the coating mainly consisted of WC and W2C. Heat treatment in the range of 400 0c – 600 0c did not result in phase transformation and did not influence the wear resistance. On the other hand, heat at 800 0c resulted in phase transformation from WC and W2C to ŋ- carbides such as (W, Co) 12C and (W, Co) 6C. Furthermore the wear resistance increased by 45% and the micro hardness increased as well. On the contrary, heat treatment at 1000 0c resulted in complete transformation of WC to ŋ-carbides and metallic W. Also, the coating surface experienced significant cracking as a result of the elevated temperature.

Parlak et al. (2005) conducted experiments on LHR engine with cylinder head, Valves and piston of the engine coated with plasma spray zirconium with the thickness of 0.5mm and it was reported that in comparison to conventional engine, specific fuel consumption was decreased by 6% and Brake Thermal Efficiency was increased by 2%. The available exhaust gas energy of the LHR engine was 3-27% higher for the LHR engine compared to the standard diesel engine.

Hanbey Hazar. (2009) Biodiesel was used as a fuel in LHR engine with ceramic coating on engine components. Experiments were conducted on LHR diesel engine with ceramic coated material Mgo-Zro2 on the cylinder head, exhaust and inlet valves while the piston surface was coated with Zro2 with canola methyl and reported that increase in engine power and decrease in specific fuel consumption, as well as significant improvements in exhaust gas emission and smoke density with LHR engine when compared with conventional engine.

Modi et al. (2010) has conducted experiment on LHR engine with ceramic coated piston crown, liner and inner surface of the cylinder head with palm oil based biodiesel and reported that LHR engine reduced smoke and marginally increased Nox emissions and thermal efficiency.

INTRODUCTION

An engine is a device, which transforms one form of energy into another form. While transforming energy from one form to another, the efficiency of conversion plays an important role. Normally, most of the engines convert thermal energy into mechanical work and therefore they are called 'heat engines'. Heat engine is a device that transforms the chemical energy of a fuel into thermal energy and utilizes this thermal energy to perform useful work. Thus, thermal energy is converted to mechanical energy in a heat engine.

The thermal efficiency of the diesel engines can be increased by reducing the heat loss to the surroundings by means of coolant and exhaust gases. The heat can be transferred from combustion chamber to piston, to the chamber walls and finally to the fins around the cylinder.

The heat transfer can be minimized by reducing the heat that is transferred from combustion chamber walls to the piston. This leads to the idea of insulating the piston and cylinder walls. These types of engines are known as low heat rejection engines (LHR) or Thermal Barrier coated engines. This can he realized by coating the pistons, cylinder walls with ceramics which can withstand with high thermal stresses. They have low thermal conductivity thus regarding to the heat flux in the piston there is a reduction of heat transfer. When the cylinder cooling losses are reduced, more of heat is delivered to the exhaust system and this efficient recovery of the engine exhaust improves the thermal efficiency of low heat rejection engines (LHR). However even without heat recovery system, some of the heat is converted into piston work and increases the thermal efficiency. Therefore, LHR engines without exhaust heat recovery systems are worth studying.

The peak burned gas temperature in the cylinder of an internal combustion engine is 1200K. Maximum metal temperatures for the inside of combustion chamber space are limited to much lower values by number of considerations and the cooling for the cylinder head, cylinder and piston must therefore be provided. These conditions lead to heat fluxes to the combustion chamber during combustion period. The fluxes vary substantially with the location. The regions of the combustion chamber that are in contact by rapidly moving high temperature burned gases experience highest fluxes and in the region of high heat fluxes thermal stresses must be below levels otherwise it would cause fatigue failure.

During the intake process, the incoming charge is usually cooler than the walls. During compression, the charge temperature rises above the wall temperature. Heat transfer is now from gases to the chamber walls. During combustion, the gases temperature increases substantially and this is the period when heat transfer rate is highest. During expansion, the gas temperature decreases and hence the heat transfer rate also decreases. Substantially the heat from the exhaust gases to the valves and ports occurring during the exhaust process decreases due to the expansion stroke.

Heat transfer effects engine performance, efficiency and emissions. For a given mass of fuel within the cylinder higher heat transfer to the combustion chamber walls will lower the average gas temperature and pressure and reduce the work per cycle transferred to the piston. Thus the power and efficiency will be affected by the magnitude of engine heat transfer, also the exhaust temperatures govern the power that can be obtained from the exhaust gas recovery devices such as turbo chargers. Hence the study of thermal barrier coating is an interesting topic to study.

EXPERIMENTAL SETUP & PROCEDURE

The details of the experimental set up are presented in this chapter and the alternations made to the instrumentation are also described .The experimental setup is fabricated to fulfill the objective of the present work. The various components of the experimental set up including modification are presented in this chapter.

EXPERIMENTAL PROCEDURE

Before starting the engine, the lubricating oil level in the engine is checked and it is also ensured that all moving and rotating parts are lubricated and check for any leakages.

At first, the engine is allowed to run with pure diesel for about 20 min, so that it gets warmed up and steady running conditions are attained.

The various steps involved in the setting of the experiment are explained below

1. The Experiments were carried out after the installation of the engine.

2. The injection pressure is set at 180 bar for the entire test.

3. Precautions were taken, before starting the experiment.

4. The engine was started at no load condition and allowed to run for at least 10 minutes to stabilize.

5. The readings such as fuel consumption, engine speed, pollution, voltage, current readings were taken as per the observation table.

6. The load on the engine was increased by 20% of full load using the engine controls and the readings were taken as shown in the tables.

7. Similarly, the load is increased gradually and the corresponding values are noted down respectively for each load

8. After completion of the test, the load on the engine was completely relieved and then the engine was stopped. 9. Now the diesel from the diesel tank is disconnected from the engine and it is connected with alternative fuel tank i.e. with 10% Sorghum Bio Diesel blend.

10. Again the engine is started with no load condition and allowed to stabilize for 20 min. After that the corresponding values are noted down.

11. Step 6, 7, 8 are repeated and the corresponding values are noted down.

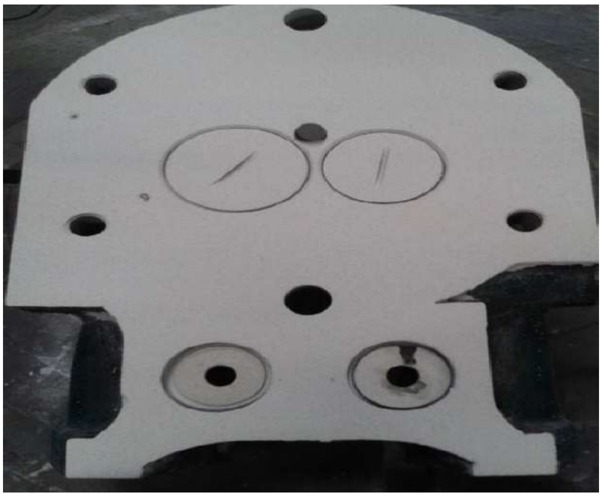
12. The same procedure is repeated with 20%, 30%, 50% Sorghum based biodiesel blends and the corresponding values are noted down.

13. Now the engine is stopped and allowed to cool for 30 minutes, so that the coated cylinder head and piston can be placed instead of conventional ones.

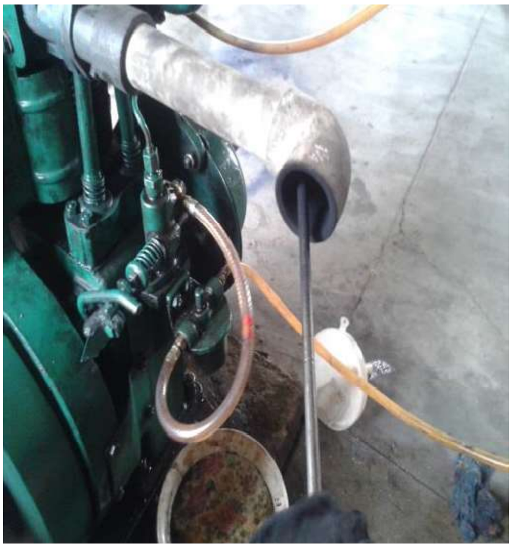
14. After replacing it with coated cylinder head and piston the readings are noted down for pure diesel with no load. Now the load is increased gradually and the corresponding values are noted down for each load.

15. The experiment is repeated with 10%, 20%, 30%, 50% Sorghum biodiesel blends and the corresponding values are noted down.

16. The engine is stopped after the experiment and the coated cylinder head and piston are replaced with conventional parts .



Cylinder head with coating **Piston crown with coating**



Piston Crown arrangement **Measurement of Exhaust by probe**

MODEL CALCULATIONS

The parameters that are determined at different loads are as fallows:

1. Brake Power, B.P = $\frac{VI\cos\emptyset}{\eta_{tran} \times \eta_{gen} \times 1000}$ kw

   Where,

   V = voltage, volts

   A = current, amperes

   Cos Ø = Power factor = 1

   η_{tran} = Transmission Efficiency = 0.98

   η_{gen} = Generator Efficiency = 0.9

   Brake Power, B.P =

2. T.F.C = $\frac{10 \times 0.85 \times 3600}{t \times 1000}$ Kg/h

   Where,

   T.F.C = Total Fuel Consumption, Kg/h

   Specific gravity of diesel = 0.85

   t =Time taken for 10 C.C fuel, sec

   T.F.C =

3. Brake Specific Fuel Consumption, bsfc = $\frac{T.F.C}{B.P}$ Kg/kWh

   Brake Specific Fuel Consumption, bsfc = Kg/kWh

3. Heat Input = T.F.C X C.V kW

   Where,

   C.V = Calorific Value of Fuel, kJ/kg k

4. Frictional Power, F.P = kW (from graph by William's line method)

5. Indicated Power = B.P + F.P

   Indicated Power = Kw

6. Mechanical efficiency = B.P/I.P x 100 %

   Mechanical Efficiency, η_{mech} = %

7. Brake thermal efficiency $= \frac{B.P}{\text{Heat Input}} \times 100\ \%$

8. Indicated thermal efficiency $= \frac{I.P}{\text{Heat Input}} \times 100\ \%$

9. Brake Mean Effective Pressure, bmep $= \frac{B.P \times 60}{L \times A \times n \times k}$

Where L = length of the stroke, m n = speed of the engine = 1500/2

A = Area of the cylinder, m^2 k = no. of cylinders

$$= \frac{B.P \times 60}{0.11 \times \frac{\pi}{4} x (0.095)^2 \times \frac{1500}{2} \times 1} = \quad kN/m^2$$

11. Indicated Mean Effective Pressure, Imep $= \frac{I.P \times 60}{L \times A \times n \times k}$

$$\frac{I.P \times 60}{0.11 \times \frac{\pi}{4} x (0.095)^2 \times \frac{1500}{2} \times 1} = \quad kN/m^2$$

RESULT AND DISCUSSIONS

BRAKE SPECIFIC FUEL CONSUMPTION

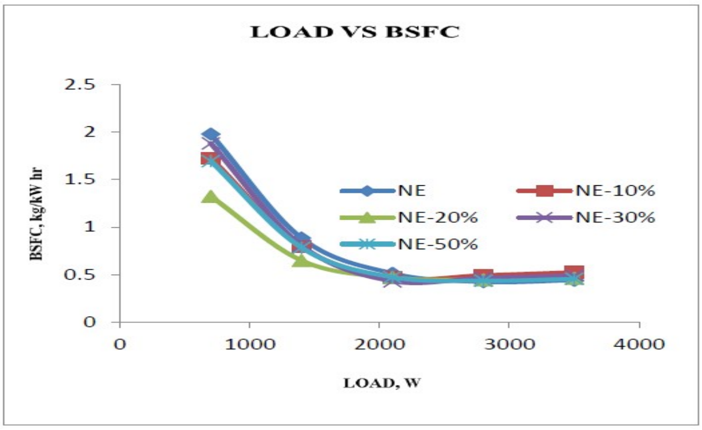


Fig 8.1.variation of bsfc with load

Above fig has been plotted for the conventional engine to observe the variations in brake specific fuel consumption (B.S.F.C) with respect to load by using diesel and various blends of sorghum based Bio-Diesel. From the figure 8.1.1 it can be observed that break specific fuel consumption decreases with increases in the load up to 2800W load and increases after that load. Further it can be noted that the trend in the variation of break specific fuel consumption with load for the engine with 10%, 20%, 30% and 50% blends of fuel is also found to be similar to that of diesel. It is important to note from the figure that break specific fuel consumption value is lowest with30% blend in comparison with all other fuels at 2100 W load. It is found after calculations that there is a maximum reduction by16.53% for 30% blend in comparison with diesel at 2100 Watts load.

However it is also noted that for the other blends of the fuel such as 10%, 20%, 50% the break specific fuel consumption value is higher than the diesel at the majority of the loads. The maximum increase in break specific fuel consumption of 10.25 % is found for the engine with 50% blend in comparison with 30% blend.

Brake Specific Fuel Consumption vs. Load for Coated Engine

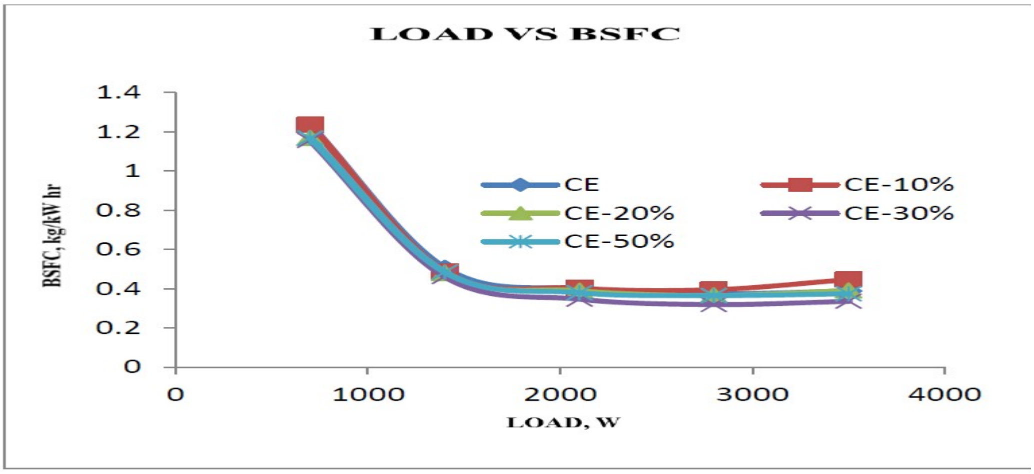
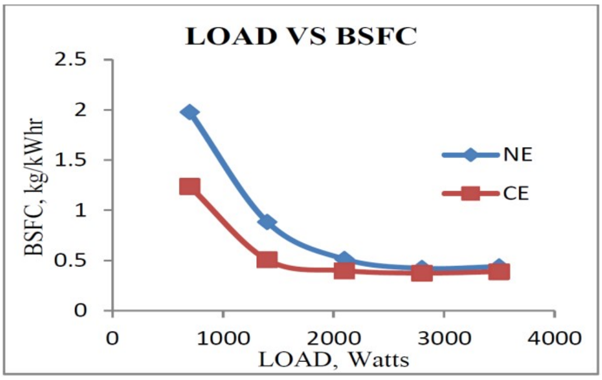


Fig 8.2.variation of bsfc with load

Above fig has been plotted for the coated engine to observe the variations in brake specific fuel consumption (B.S.F.C) with respect to load by using diesel and various blends of sorghum based Bio-Diesel. From the figure 8.1.2 it can be observed that break specific fuel consumption decreases with increases in the load up to 2800W load and increases after that load. Further it can be noted that the trend in the variation of break specific fuel consumption with load for the engine with 10%, 20%, 30% and 50% blends of fuel is also found to be similar to that of diesel. It is important to note from the figure that break specific fuel consumption value is lowest with 30% blend in comparison with all other fuels at all other points of the load. It is found after calculations that there is a maximum reduction by 13.6% for 30% blend in comparison with diesel at 2100 Watts load.

However it is also noted that for the other blends of the fuel such as 10%, 20%, 50% the break specific fuel consumption value is higher than the diesel at all the values of the load. The maximum increase in break specific fuel consumption of 16.47% is found for the engine with 50% blend in comparison with 30% blend

Brake specific fuel consumption vs. Load for coated and conventional Engine



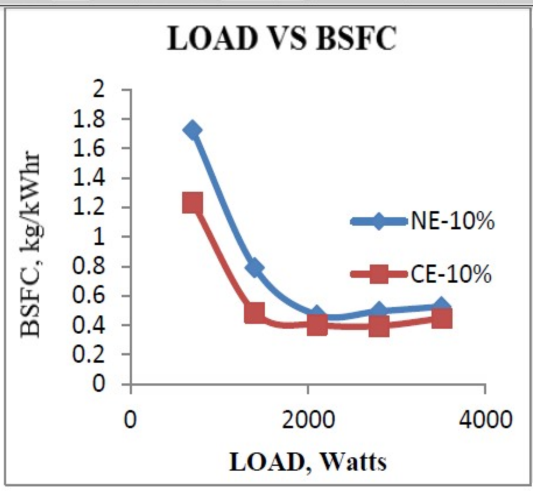


Fig 8.3. b .variation of bsfc with load

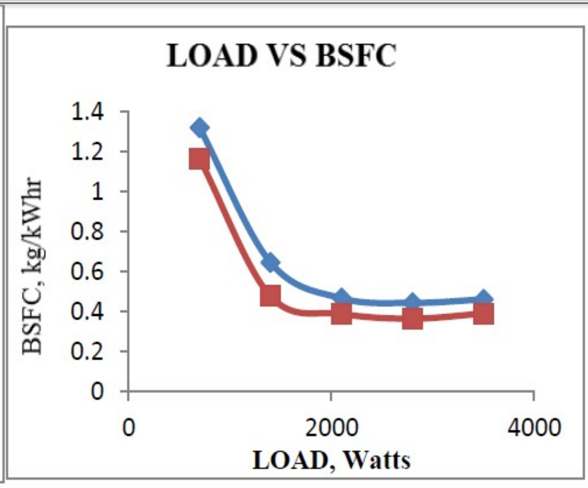


Fig 8.3.c.variation of bsfc with load

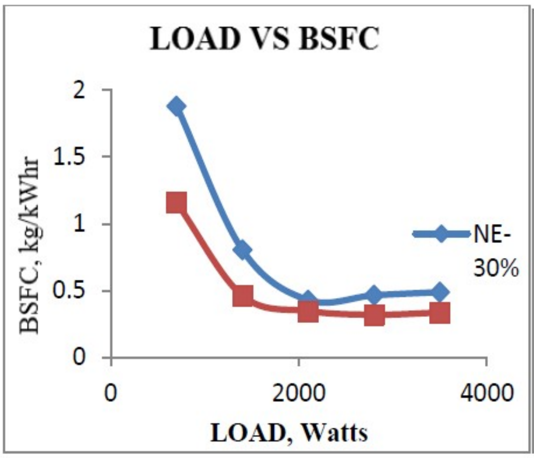


Fig 8.3.d.variation of bsfc with load

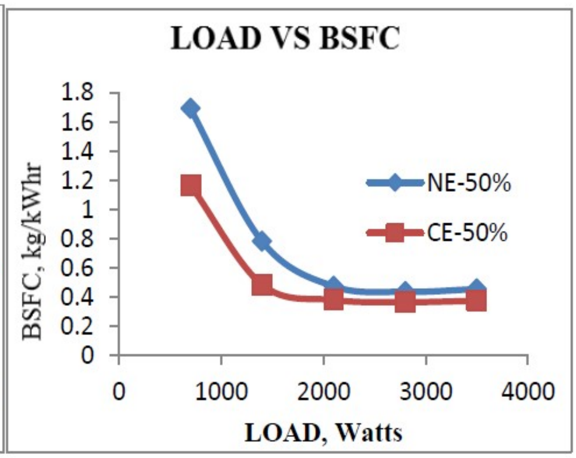


Fig 8.3.e.variation of bsfc with load

Fig8.1.3a, 8.1.3b, 8.1.3c, 8.1.3d,8.1.3e has been plotted for the conventional and coated engine to observe the variations of brake specific fuel consumption (B.S.F.C) by using diesel and various blends of sorghum based Bio-Diesel. From the figures it can be observed that B.S.F.C decreases with increase in the load up to 2800 W load and then increases after that load. Further it can be noted that, the trend in the variation of B.S.F.C with load for the engine with 10%, 20%, 30%, and 50% blends of fuel is found to be similar to that of diesel. It is important to note from the figure that B.S.F.C value is lowest with 30% blend in comparison with all other fuels at all other points of the load in both the coated and conventional engines. It is found after calculations that there is a maximum decrease of B.S.F.C by 2.5% for 30% blend in comparison with diesel at 2100 Watts load with coated engine and whereas for the conventional engine there is a maximum decrease of 8.46%. Similarly, the maximum increase in B.S.F.C of 20% is found for the engine with 50% blend in comparison with 30% blend at 2100W load with coated engine. Whereas a maximum increase of 9.24% is found for the conventional engine in comparison with same blend and same load of that by coated engine.

Brake specific fuel consumption vs. Load

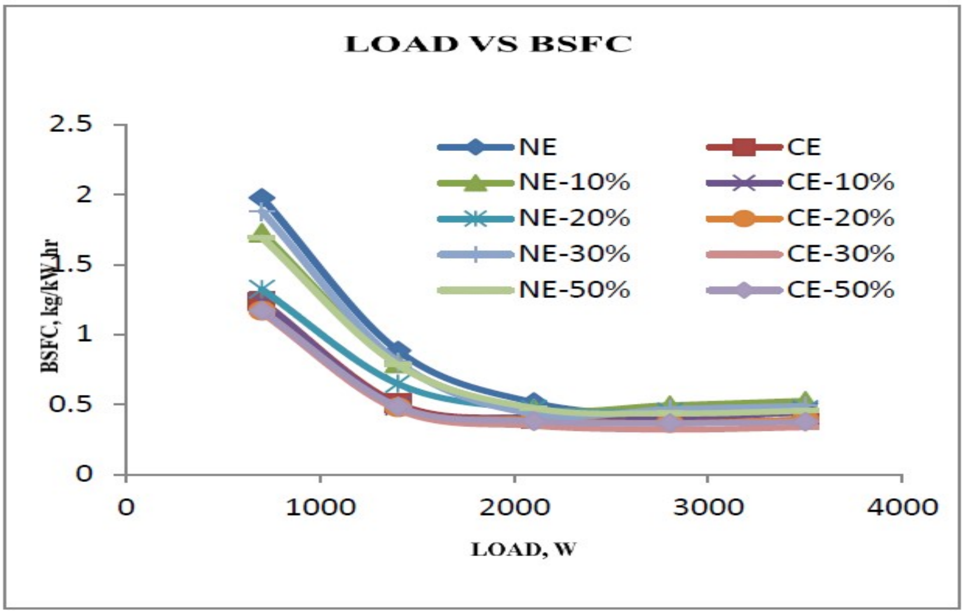


Fig 8.4.variation of bsfc with load

Fig No. 8.4 has been plotted for the conventional engine and coated engine to observe the variations of Brake specific fuel consumption (B.S.F.C) by using diesel and various blends of sorghum based Bio-Diesel. From the figure it can be observed that B.S.F.C decreases with increase in the load up to 2800W load and increases after that load. Further it can be noted that the trend in the variation of B.S.F.C with load, for the engine with 10%, 20%, 30% and 50% blends of fuel is found to be similar to that of diesel. It is important to note from the figure that B.S.F.C value is lowest with 30% blend, for coated engine in comparison with all other fuels at all other points of the load.

It is found after calculation that there is a maximum reduction by 32.68% for coated engine 30% blend in comparison with conventional engine pure diesel at 2100watts load. It is also found after calculations that there is a maximum decrease by 13.06% with coated engine for diesel fuel in comparison with conventional engine. However it is noted that for the other blends of the fuel such as 10%, 20%, 30% and 50% the B.S.F.C decreases by 13.89%, 16.70%, 19.34% and 20.08% respectively with coated engine in comparison with conventional engine. The maximum decrease in B.S.F.C of 9.48% is found with coated engine 30% blend in comparison with conventional engine 50% blend.The improvement in fuel economy achieved by thermal barrier coated engine may be attributed, higher premixed combustion, lower diffusion combustion, reduced heat transfer loss and higher rate of heat release in the main portion of combustion.

BRAKE THERMAL EFFICIENCY

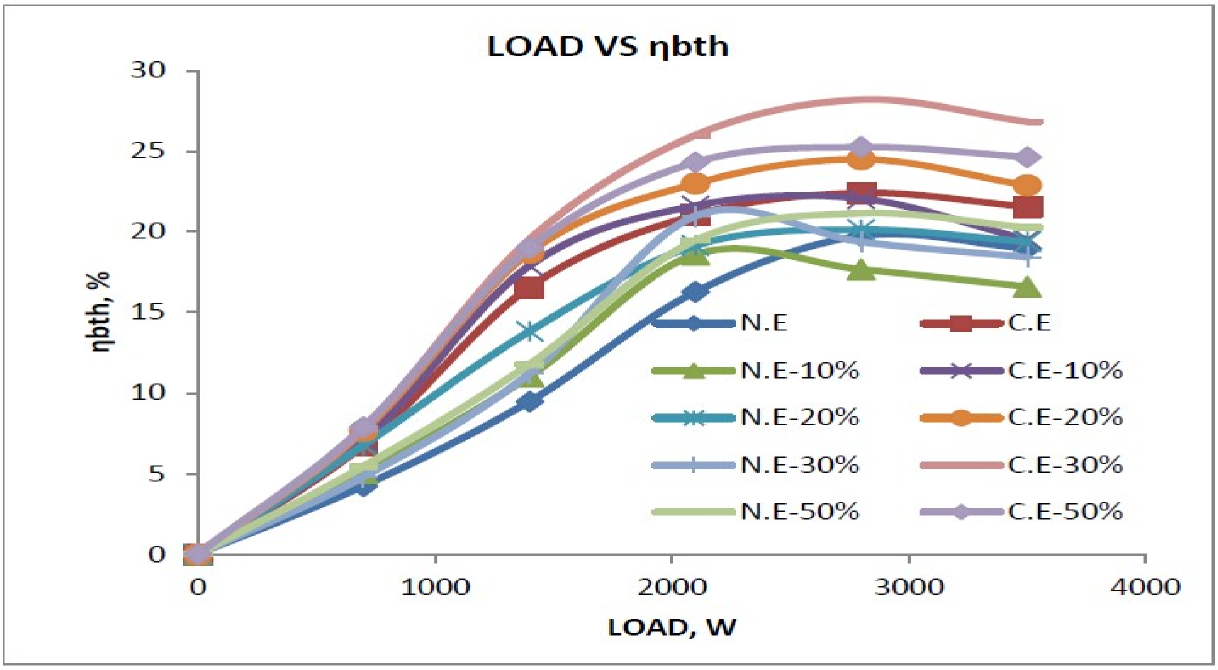


Fig 8.8.variation of η_{bth} with load

Fig No. 8.8 Has been plotted for the conventional engine and coated engine to observe the variations of brake thermal efficiency by using diesel and various blends of sorghum based Bio-Diesel. From the figure it can be observed that brake thermal efficiency increases with increase in the load up to 2800W load and reduces after that load Further it can be noted that the trend in the variation of brake thermal efficiency with load for the engine with 10%, 20%, 30%, and 50% blends of fuel is found to be similar to that of diesel. It is important to note from the figure that brake thermal efficiency value is highest with 30% blend for coated engine in comparison with all other fuels at all other points of the load.

It is found after calculation that there is a maximum increase by59.37% for coated engine 30% blend in comparison with conventional engine pure diesel at 2100watts load. It is also found after calculations that there is a maximum increase by23.5% with coated engine for diesel fuel in comparison with conventional engine. However it is noted that for the other blends of the fuel such as 10%, 20%, 30% and 50% the brake thermal efficiency increases for coated engine by 16.25%, 20.06%, 23.89% and 24.93% respectively in comparison with conventional engine. The maximum decrease in brake thermal efficiency of 6.46% is found with conventional engine 50% blend in comparison with coated engine 30% blend.

MECHANICAL EFFICIENCY

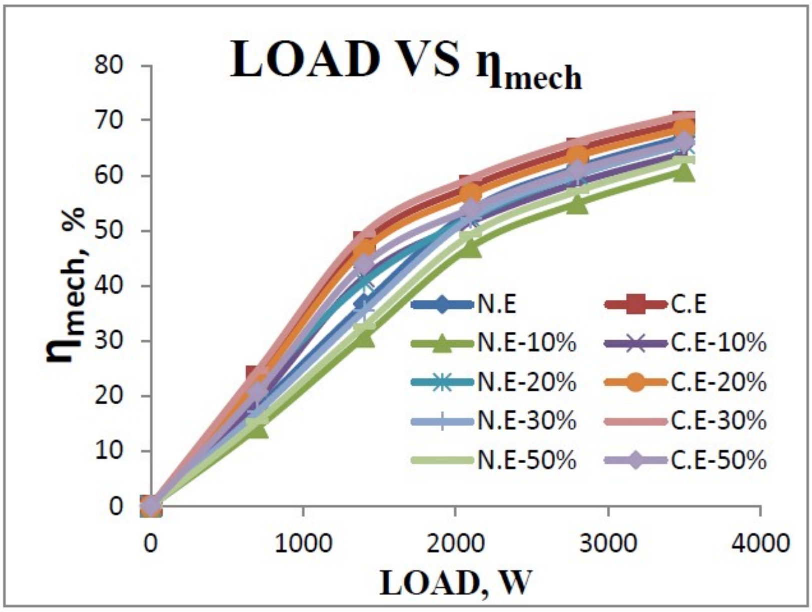


Fig.8.17.variation of η_{mech} with load

Fig. No. 8.17 Has been plotted for the conventional engine and coated engine to observe the variations of mechanical efficiency by using diesel and various blends of sorghum based Bio-Diesel. From the figure it can be observed that mechanical efficiency increases with increase in the load.

Further it can be noted that the trend in the variation of mechanical efficiency with load for the engine with 10%, 20%, 30%, and 50% blends of fuel is found to be similar to that of diesel. It is important to note from the figure that mechanical efficiency value is highest with30% blend for coated engine in comparison with all other fuels at all other points of the load. It is found after calculation that there is a maximum increase by 10.76% for coated engine 30% blend in comparison with conventional engine pure diesel at 2100watts load. It is also found after calculations that there is a maximum increase by2.53% with coated engine for diesel fuel in comparison with conventional engine. However it is noted that for the other blends of the fuel such as10%, 20%, 30% and 50% the mechanical efficiency increases for coated engine by 16.91%, 7.52%, 11.99% and 8.79 respectively with conventional engine. The maximum decrease in mechanical efficiency of14.28% is found with conventional engine 50% blend in comparison with coated engine 30% blend.

CARBON MONOXIDE

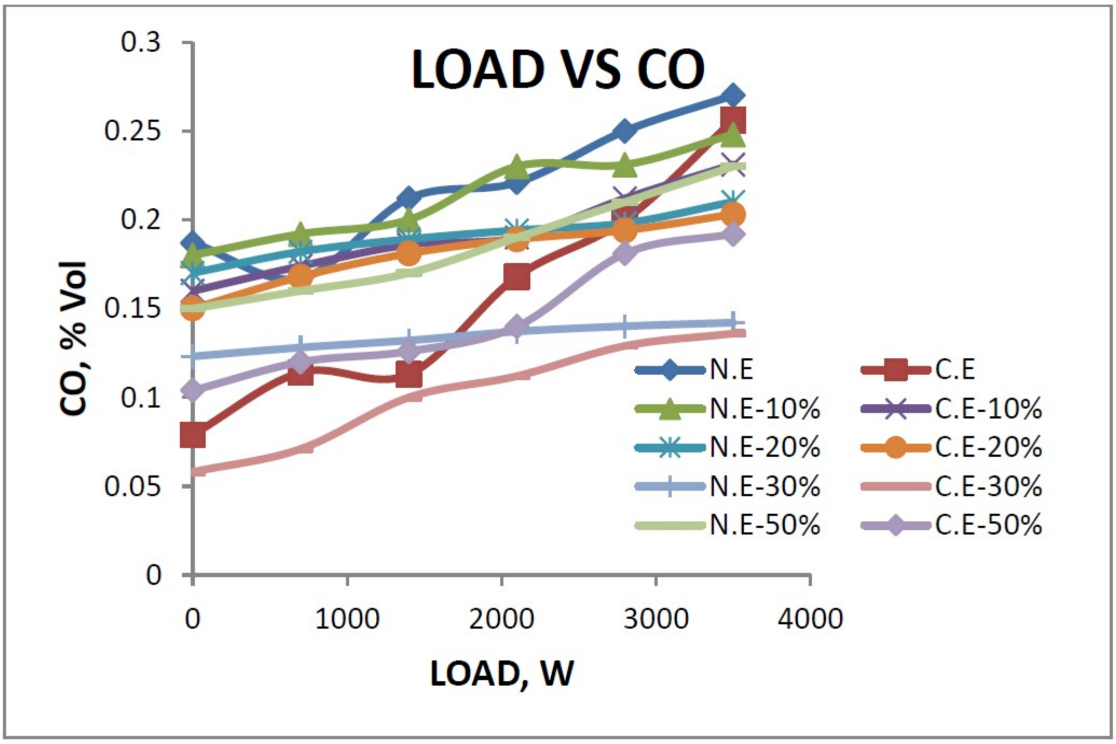


Fig.8.21.variation of CO with load

Fig No.8.21 has been plotted for the conventional engine and coated engine to observe the variations of Carbon monoxide (CO) by using diesel and various blends of sorghum based Bio-Diesel. From the figure it can be observed that Carbon monoxide increases with increase in the load.

Further it can be noted that the trend in the variation of Carbon monoxide with load, for the engine with 10%, 20%, 30% and 50% blends of fuel is found to be similar to that of diesel. It is important to note from the figure that Carbon monoxide value is lowest with 30% blend, for coated engine in comparison with all other fuels at all other points of the load.

It is found after calculation that there is a maximum reduction by49.32% for coated engine 30% blend in comparison with conventional engine pure diesel at 2100watts load. It is also found after calculations that there is a maximum decrease by 21.16% with coated engine for diesel fuel in comparison with conventional engine. However it is noted that for the other blends of the fuel such as 10%, 20%, 30% and 50% the Carbon monoxide decreases by 17.39%, 2.57%, 18.24% and 26.31% respectively with coated engine in comparison with conventional engine. Lower percentage of CO indicates better or complete combustion.

CARBON DIOXIDE

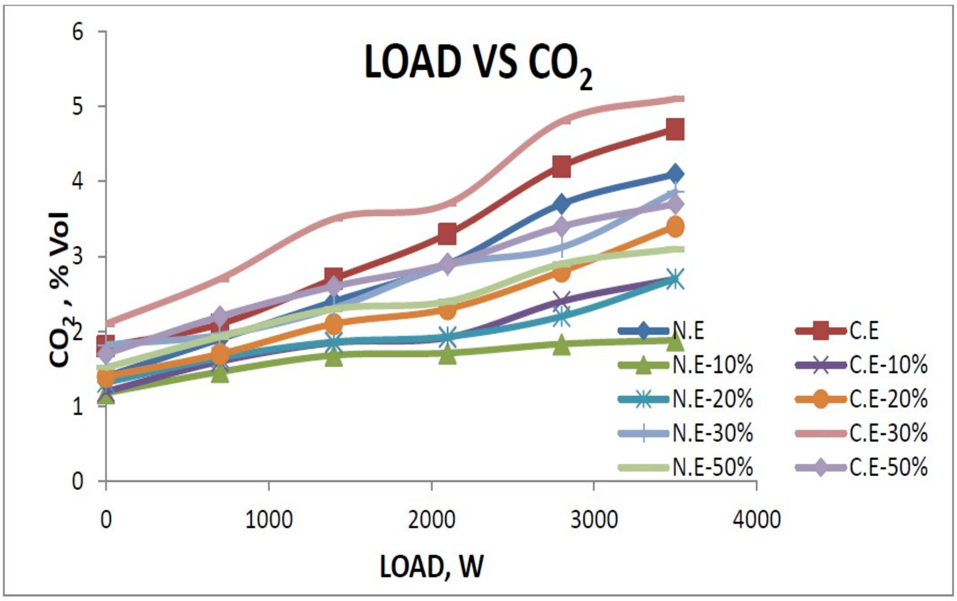


Fig.8.25.variation of CO_2 with load

Fig. No. 8.25 Has been plotted for the conventional engine and coated engine to observe the variations of carbon dioxide (co2) by using diesel and various blends ofsorghum based Bio-Diesel. From the figure it can be observed that carbon dioxide increases with increase in the load.

Further it can be noted that the trend in the variation of carbon dioxide with load for the engine with 10%, 20%, 30%, and 50% blends of fuel is found to be similar to that of diesel. It is important to note from the figure that carbon dioxide value is highest with30% blend for coated engine in comparison with all other fuels at all other points of the load.

It is found after calculation that there is a maximum increase by 27.58% for coated engine 30% blend in comparison with conventional engine pure diesel at 2100watts load. It is also found after calculations that there is a maximum increase by 13.79% with coated engine for diesel fuel in comparison with conventional engine. However it is noted that for the other blends of the fuel such as 10%, 20% the carbon dioxide increases for coated engine by 12.28% and 19.17%, respectively with conventional engine. The maximum decrease in carbon dioxide of 35.13% is found with conventional engine 50% blend in comparison with coated engine 30% blend.

OXIDES OF NITROGEN

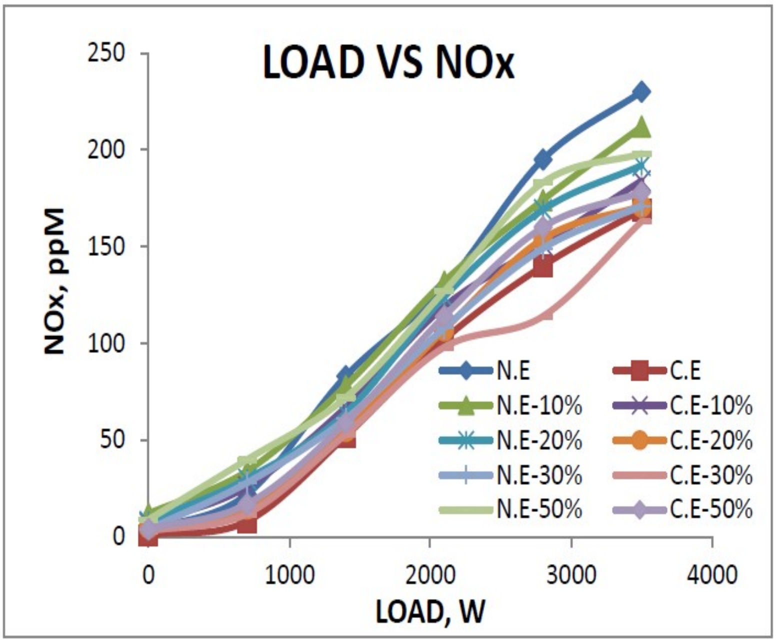


Fig.8.29 variation of NOx with load

Fig No.8.29 has been plotted for the conventional engine and coated engine to observe the variations of Oxides of Nitrogen (NOx) by using diesel and various blends of sorghum based Bio-Diesel. From the figure it can be observed that NOx increases with increase in the load.
Further it can be noted that the trend in the variation of NOx with load, for the engine with 10%, 20%, 30% and 50% blends of fuel is found to be similar to that of diesel. It is important to note from the figure that NOx value is lowest with 30% blend, for coated engine in comparison with all other fuels at all other points of the load.
It is found after calculation that there is a maximum reduction by 24.03% for coated engine 30% blend in comparison with conventional engine pure diesel at 2100watts load. It is also found after calculations that there is a maximum decrease by 20.93% with coated engine for diesel fuel in comparison with conventional engine. However it is noted that for the other blends of the fuel such as 10%, 20%, 30% and 50% the NOx decreases by 9.84%, 13.7%, 9.25% and 10.23% respectively with coated engine in comparison with conventional engine. The maximum decrease in NOx of 22.83% is found with coated engine 30% blend in comparison with conventional engine 50% blend.
The decrease of NOX in coated engine can be attributed to the thermal barrier coating i.e. Magnesia stabilized zirconia, where Magnesia observes Nitrogen at higher temperatures, there by releasing lower amount of NOx.

HYDRO CARBON EMISSIONS

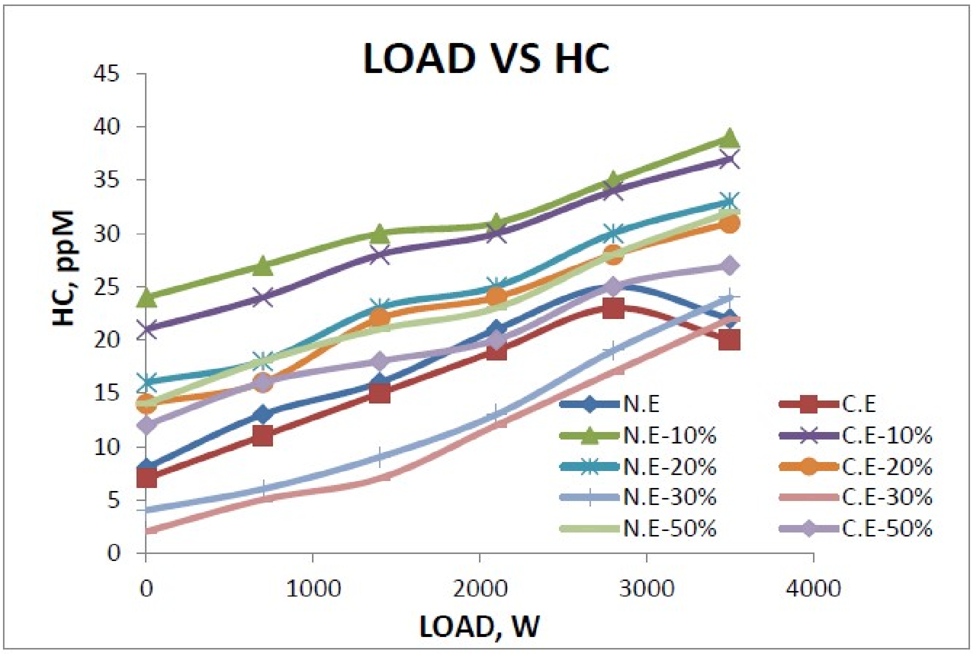


Fig.8.34.variation of HC with load

Fig No8.34 has been plotted for the conventional engine and coated engine to observe the variations of hydro carbon emissions (HC) by using diesel and various blends of sorghum based Bio-Diesel. From the figure it can be observed that hydro carbons emissions increase with increase in the load.

Further it can be noted that the trend in the variation of hydro carbon emissions with load, for the engine with 10%, 20%, 30% and 50% blends of fuel is found to be similar to that of diesel. It is important to note from the figure that hydro carbons emissions value is lowest with 20% blend, for coated engine in comparison with all other fuels at all other points of the load.

It is found after calculation that there is a maximum reduction by 42.85% for coated engine 30% blend in comparison with conventional engine pure diesel at 2100watts load .It is also found after calculations that there is a maximum decrease by 7.69% with coated engine for diesel fuel in comparison with conventional engine. However it is noted that for the other blends of the fuel such as 10%, 20%, 30% and 50% the HC decreases by 7.14%, 16.66%, 6.66% and 11.11% respectively with coated engine in comparison with conventional engine. The maximum decrease in hydro carbon emissions of 44.44% is found with coated engine 20% blend in comparison with conventional engine 50% blend.

Unburnt hydro carbon emissions are because of incomplete combustion and it is clear that hydrocarbon emissions are decreasing because of thermal barrier coating, which results in better combustion, due to the increase in heat energy in the combustion chamber

CONCLUSIONS

In regard with the experimental investigation on the performance and emission characteristics of a direct injection diesel engine by using Thermal Barrier Coating (TBC) on piston and cylinder head, the following conclusions are drawn:

1. The Brake Specific fuel consumption is decreased by 32.68% for coated engine with 30% blend in comparison with conventional engine with pure diesel at 2100 Watts load.

2. The Brake thermal efficiency of the engine is increased about 9.72% for coated engine with 30% blend in comparison with conventional engine with pure diesel at 2100 Watts load.

3. The Mechanical efficiency of the engine is increased about 5.78 % (i.e. from 53.68to59.46) for coated engine with 30% blend in comparison with conventional engine with pure diesel at 2100 Watts load.

4. The indicated mean effective pressure is decreased about 1.54% for coated engine with 30% blend in comparison with conventional engine with pure diesel at 2100 Watts load.

5. The HC emissions are lower than Bharat Stage –IV permissible limits, with all the fuels at all the points of load. And the HC emissions are decreased about 42.85% for coated engine with 30% blend in comparison with conventional engine with pure diesel at 2100 Watts load.

6. The CO emissions are lower than Bharat Stage –IV permissible limits, with all the fuels at all the points of load. And the CO emission of the engine is decreased about 0.165% (i.e. from 0.1 to 0.265) for coated engine with 30% blend in comparison with conventional engine with pure diesel at 2100 Watts load.

7. The CO2 emission of the engine is increased about 0.8% (i.e. from 2.9 to 3.7 % vol) for coated engine with 30% blend in comparison with conventional engine with pure diesel at 2100 Watts load.

8. The NOx emissions of the engine are decreased about24.03% (i.e. from 129 to 114 ppm) for coated engine with 30% blend in comparison with conventional engine with pure diesel at 2100 Watts load.

From the present experimental work, it is evident that for coated engine, with 30% sorghum Biodiesel gives improved performance and reduced emissions.

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