

EFFECTS OF TUNGSTEN CARBIDE COATING ON C.I. ENGINE USING MANGOSEED OIL DIESEL BLENDS

Dr. K. Kalyani Radha¹ Dr. B. Omprakash²

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: Diesel Engines are the major source of Transportation, Power generation, Marine applications etc., hence diesel engines are being used extensively for fuel economy but due to gradual depletion of world Petroleum resources and the impact on the environment by increase in exhaust gas emissions, there is an urgent need for suitable alternative fuels for the Diesel Engines. In view of this, the various vegetable oils like Mangoseed oil, Jatropa, Palm oil, Sunflower oil, Neem oil, Cotton seed oil etc., are considered as the alternative fuels for the diesel engines. Ceramic coatings like Tungsten Carbide on piston crown are increasingly used to provide protection, helping to increase wear resistance, reduce friction, and improve heat shielding. These factors have a significant influence on horsepower ratings, and augmenting them through ceramic coating can often enhance an automobile's performance. Hence an attempt is made to analyze the performance and emission characteristics of diesel and different blends of Mangoseed oil using Tungsten carbide coated piston on a four stroke single cylinder water cooled Diesel Engine test rig in I.C Engines Laboratory. Experiments were carried out on a four stroke single cylinder diesel engine using Mangoseed oil and Diesel namely B10, B20, B30, and B40 on volume basis. Performance parameters such as brake power, specific fuel consumption, and thermal efficiencies are calculated based on experimental analysis of the engine. Emissions such as carbon monoxide, carbon dioxide, NO_x and unburned hydrocarbon are measured. The test results indicate that blend B20 (20% Mango seed oil & 70% Diesel) gives better performance and emission results compared to all fuel mixtures and diesel under this study.

Keywords: Mango Seed Oil (MSO), Tungsten Carbide, single cylinder 4-stroke diesel engine, Engine performance.

I. INTRODUCTION

According to the present scenario diesel engines are commonly used as prime movers in the transportation, industrial and agricultural sectors because of their high brake thermal efficiency and reliability. Energy conservation and efficiency have always been the quest of the engineers. But due to gradual depletion of world petroleum reserves and the impact of environmental pollution of increasing exhaust emissions, there is an urgent need for suitable alternative

fuels for use in diesel engines. In view of this, various oils like Mango seed oil, jatropa, palm oil, sunflower oil etc., are considered as alternate fuels to diesel which are promising alternatives because they have the advantages – they are renewable, eco-friendly and produced easily in rural areas, where there is an acute need for modern forms of energy. If these fuels serve the purpose of diesel to some extent they will be useful to the rural areas in providing employment as well as agriculture energy needs. If these fuels serve the purpose to a larger extent they will be good substitutes in industrial, transportation etc.

Investigations have been carried out globally to replace conventional fossil fuel with suitable alternate fuel which is renewable in nature and available throughout the world. The advantages of biofuel apart from the renewability are: High oxygen content, higher flash point and higher lubricity that produces complete combustion in comparison with conventional diesel fuel. Further, the environmental benefit is another investigation factor due to a lesser greenhouse effect, less air pollution, less contamination for water and soil and reduced health risk. Biofuel contains sulfur free, thus the issue of acid rain is therefore ameliorated

Ceramic coatings applied to diesel engine combustion chambers are aimed to reduce heat which passes from in-cylinder to engine cooling system. Engine cooling systems are planned to be removed from internal combustion engines by the development of advanced technology ceramics. One can expect that engine power can be increased and engine weight and cost can be decreased by removing cooling system elements (coolant pump, ventilator, water jackets and radiators etc.). More silent engine operation can be obtained considering less detonation and noise causing from uncontrolled combustion. Another important topic from the view point of internal combustion engines is exhaust emissions. Increased combustion chamber temperature of ceramic coated internal combustion engines causes a decrease in soot and carbon monoxide emissions.

II. LITERATURE SURVEY

AydinHuseyin [1] examined the “Combined effects of thermal barrier coating and blending with diesel fuel on usability of

vegetable oils in diesel engines". The possibility of using pure vegetable oils in a thermally insulated diesel engine has been experimentally investigated. Initially, the standard diesel fuel was tested in the engine, as base experiment for comparison. Then the engine was thermally insulated by coating some parts of it, such as piston, exhaust and intake valves surfaces with zirconium oxide (ZrO_2). The main purpose of engine coating was to reduce heat rejection from the walls of combustion chamber and to increase thermal efficiency and thus to increase performance of the engine that using vegetable oil blends. Another aim of the study was to improve the usability of pure vegetable oils in diesel engines without performing any fuel treatments such as pyrolysis, emulsification and trans esterification. Pure inedible cottonseed oil and sunflower oil were blended with diesel fuel. Blends and diesel fuel were then tested in the coated diesel engine. Experimental results proved that the main purpose of this study was achieved as the engine performance parameters such as power and torque were increased with simultaneous decrease in fuel consumption (BSFC). Furthermore, exhaust emission parameters such as CO, HC, and Smoke opacity were decreased. Also, sunflower oil blends presented better performance and emission parameters than cottonseed oil blends.

Helmisyah A.J., Ghazali [2] "Characterization of Thermal Barrier Coating on Piston Crown for Compressed Natural Gas Direct Injection (CNGDI) Engines" has presented the high temperature and pressure produced in an engine that uses compressed natural gas with direct injection system (CNGDI) may lead to high thermal stresses. The piston crown fails to operate effectively with insufficient heat transfer. In this study, partially stabilized zirconia (PSZ) ceramic thermal barrier coatings were plasma sprayed on CNGDI piston crowns (AC8A aluminum alloys) to reduce thermal stresses. Several samples were deposited with NiCrAl bonding layers prior to the coating of PSZ for comparison purposes. Detailed analyses of microstructure, hardness, surface roughness, and interface bonding on the deposited coating were conducted to ensure its quality. High stresses were mainly concentrated above the pinhole and edge areas of the piston. In short, the PSZ/ NiCrAl coated alloys demonstrated lesser thermal stresses than the uncoated piston crowns despite a rough surface. Extra protection is thus given during combustion operation.

VinayKumar., RaviKumar., .SantoshKumari [3]"Prediction of Performance and Emissions of a Biodiesel Fueled Lanthanum Zirconate Coated Direct Injection Diesel engine using Artificial Neural Networks "has presented different techniques are being attempted over the years to use low pollution emitting fuels in diesel engines to reduce tail pipe emissions with improved engine efficiency. Especially, Biodiesel fuel, derived from different vegetable oils, animal fat and waste cooking oil has received a great attention in the

recent past. Trans esterification is a proven simplest process to prepare biodiesel in labs with little infrastructure. Application of thermal barrier coatings (TBC) on the engine components is a seriously perused area of interest with low grade fuels like biodiesel fuels. Artificial neural networks (ANN) are gaining popularity to predict the performance and emissions of diesel engines with fairly accurate results besides the thermodynamic models with considerably less complexity and lower computing time.

III. MANGO SEED OIL (MSO)



Fig.1: Mango seed kernels

Raw waste mango seeds are collected from many places especially from mango juice centers and mango pickles industries. These seeds are dried at room temperature about 15 days. The outer cover from the seed was broken to get the kernel from the seed. The mango seed kernel is dried again at room temperature for 5 days. The kernel is broken into pieces and then subjected to crushing with the crusher machine. During crushing at one stage the oil was derived. Raw mango seed oil is slight yellowish in Colour, less volatile and having the combustible mixture of hydro carbons.

IV EXPERIMENTAL WORK

In order to analyze the performance and emission characteristics of internal combustion engine, an experimental set-up was developed. In the present work, tungsten carbide (WC) was coated on piston crown and mango seed oil was used as biodiesel on volume basis. The experiment was carried out on a single cylinder 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.



Fig 2: Experimental setup



Fig 3: Titanium Oxide coated piston

TABLE 1

TEST ENGINE SPECIFICATIONS

Particulars	Specifications
Model	AVI
Make	Kirloskar Oil Engine Ltd.
Arrangement of cylinders	Vertical
No of cylinders	1
Lubricant	SAE40
Bore	85mm
Stroke length	110mm
Rated speed	1500 rpm
Rated power	5HP
Starting	Hand start with crank handling
Type of cooling	Water cooled

V. RESULTS AND DISCUSSIONS

1. Brake Specific Fuel Consumption:

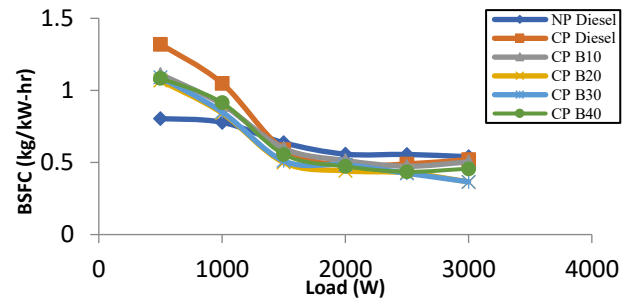


Fig 4: Load vs. Brake specific fuel consumption

The result for the variations in the brake specific fuel consumption (BSFC) with load is presented in the Fig.3. From fig.4 it can be clearly seen that the BSFC of WC coated engine for different biodiesel blends is lower than the standard engine with diesel fuel at full load. The main reason is that the ceramic materials act as barrier for the heat transfer to the surroundings from the combustion chamber and reduces the heat loss from the engine. Also the reduction in heat loss will ultimately increase the power output and thermal efficiency of the engine and this lead to reduce the BSFC. The BSFC values at full load are 0.540 kg/kW-hr for diesel (standard engine), 0.52 kg/kW-hr for diesel (WC coated piston) and 0.504, 0.366, 0.416, 0.457 kg/kW-hr for the Mango seed oil blends respectively.

2. Brake Thermal Efficiency: The variation of brake thermal efficiency with respect to load for Mango seed oil blends and diesel are shown in Fig.5. It can be observed from the results that the WC coated piston improves the thermal efficiency when compared with uncoated engine. This may be due to increased temperature of the piston crown which increases the temperature of cylinder gas and wall results in higher temperature at combustion chamber. The combustion conditions become more favorable which results in shortening ignition delay time in coated engine affecting both the chemical and physical reactions positively. It can be observed that the WCcoated engine fueled with B20 gives brake thermal efficiency of 23.5% which is more compared to the other blends at full load.

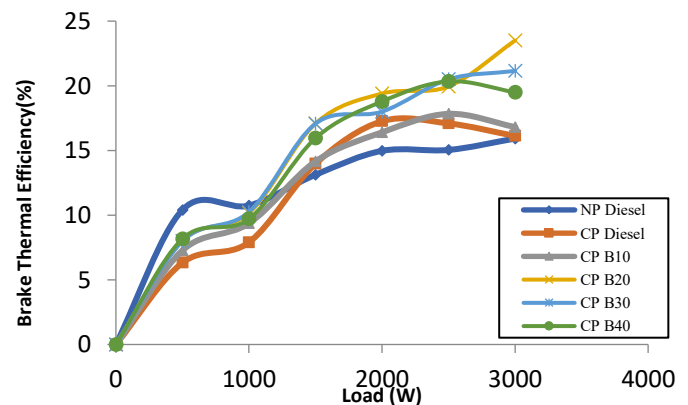


Fig 5: Load vs Brake thermal efficiency

Fig 7: Load vs Carbon dioxide

3. Exhaust Gas Emissions of Carbon Monoxide:

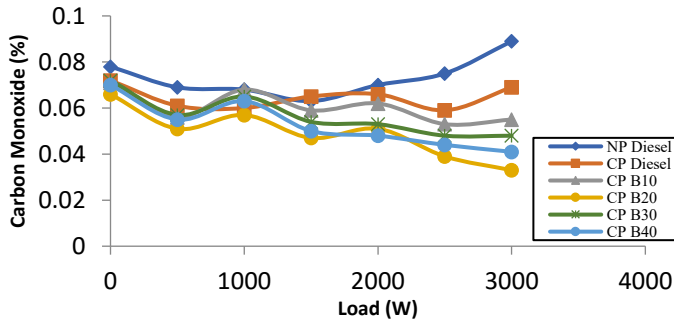
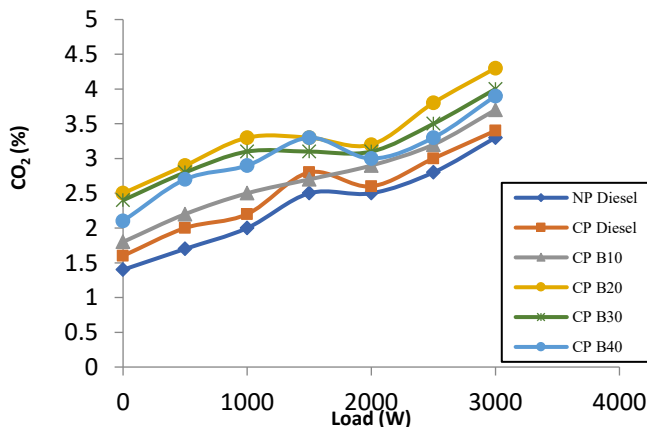


Fig 6: Load vs Carbon monoxide

From Fig.6 the variation of carbon monoxide with respect to load can be observed for both coated and normal piston engines. It is clear that CO is decreased after the coating due to the complete combustion. CO emission from diesel engine is related to the fuel properties as well as combustion characteristics. It is well known that better fuel combustion usually resulted in lower CO emission. The carbon monoxide, which arises mainly due to incomplete combustion, is a measure of combustion efficiency. Generally, oxygen availability in diesel fuel and biodiesel blends is high so at high temperatures carbon easily combines with oxygen and reduces the CO emission. The results show that CO emission of standard engine (diesel) slightly higher than WCcoated piston engine at full load condition. Carbon monoxide from the exhaust gas for the diesel fuel (standard engine) is 0.089% by vol. and for WC coated piston engine using blends B0, B10, B20, B30 and B40 are 0.069, 0.055, 0.033, 0.048, and 0.041% by vol. respectively. It is clear that the emissions concentrations are lower than Bharath Stage III.

4. Exhaust Gas Emissions of Carbon dioxide:



As shown in Fig.7, the variation of carbon dioxide emissions with respect to load can be observed. From the results, it is observed that the amount of CO₂ produced while using Mango seed oil blends are higher than diesel at full load condition, this indicates the complete combustion of fuel. Carbon dioxide from the exhaust gas for the diesel fuel (standard engine) is 3.3% vol. and for WC coated piston engine for different blends of Mango seed oil are 3.4, 3.7, 4.3, 4 and 3.9% by vol. respectively. As a general rule, the higher the carbon dioxide reading, the more efficient the engine is operating [9]

5. Exhaust Emissions of Hydrocarbon Emissions

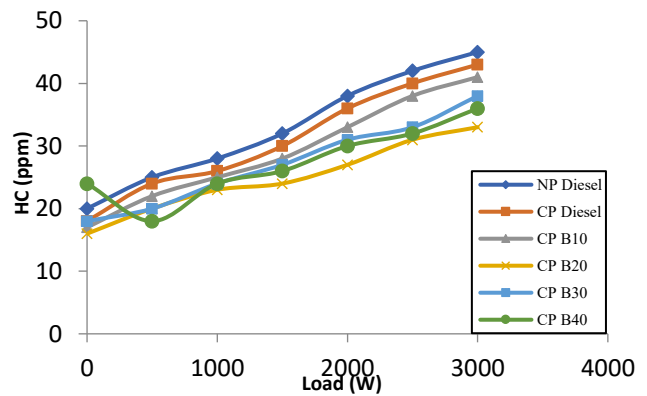


Fig 8: Load vs Hydro Carbons

The variation of hydrocarbons with respect to load for tested fuels is depicted in Fig.8. From the results, it can be noticed that the concentration of hydrocarbon of Mango seed blends is slightly lower than diesel. Unburnt hydrocarbon from the exhaust gas at full load for the diesel fuel (standard engine) is 45ppm and for coated piston engines using Mango seed oil blends B0, B10, B20, B30, B40 are 43ppm, 41ppm 33ppm, 38ppm, and 36ppm respectively. It can be observed from the results that Thermal Barrier Coating (WC) in piston crown decreasing HC when compared with uncoated engine. The HC emission reduces because of an increase in residual gas temperature with in the cylinder and decrease in flame quenching thickness at higher load in the engine. It is cleared that the emissions concentration for all the blends are lower than Bharath Stage III norms [10].

6. Exhaust Emissions of Nitrogen Oxides:

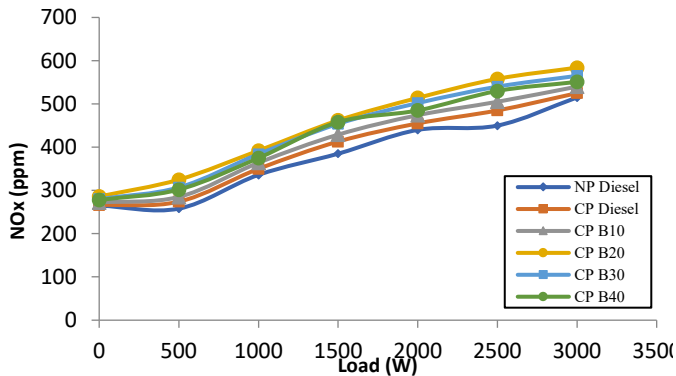


Fig 9: Load vs Nitrogen oxides

From Fig.9, the variation of nitrogen oxides with respect to load can be observed for both coated and normal piston engine for different blends. The formation of nitrogen oxide emissions depends on the heat transfer rate and evaporation rate of the fuel. This increases further, with the availability of oxygen and the higher prevailing temperatures in the chamber [11]. With the ceramic coating the heat in the chamber is higher which further increases the evaporation rate of the fuel. NO_x from the exhaust gas for the diesel fuel (standard engine) is 515 ppm and for WC coated piston engine for different blends of Mango seed oil B0, B10, B20, B30, and B40 are 525, 540, 584, 565 and 551 ppm respectively [12].

VI. CONCLUSIONS

Performance and emission characteristics of diesel (C.I) engine with blends of biodiesel of mango seed oil with diesel and Tungsten Carbide as piston coating are compared with the normal diesel engine in this experimental investigation. From this investigation, it can be concluded that blend B20 gives better performance and emission results compared to the all blends and diesel. The results of this study may be summarized as follows.

- It is observed that reduction of BSFC for engine with Tungsten carbide using mango seed oil blends as compared to the normal engine with diesel at all load conditions. Blend B20 has BSFC 0.366kg/kW-hr which is very compared to other blends at full load.
- Brake Thermal efficiency of the tested diesel engine is improved when it is fuelled with Mango seed oil-diesel blends operating on WCcoated piston. Blend B20 gives brake thermal efficiency of 23.5% which is more when compared to other blends at full load.
- CO emissions of biodiesel are less compared to diesel; it is likely due to oxygen content present in the biodiesel. Blend B20 gives CO emission 0.033% by vol which is less when compared to all the blends and diesel.

- It is observed that the amount of CO₂ produced while using Mango seed oil blend B20 gives 4.3% by Vol which is higher than diesel and other blends at full load condition, this indicates the complete combustion of fuel.

- It can be observed from the results that Thermal Barrier Coating (WC) in piston crown decreasing HC when compared with uncoated engine. The HC emission reduces because of an increase in residual gas temperature with in the cylinder and decrease in flame quenching thickness at higher load in the engine. Blend B20 gives HC emission 33ppm which is less when compared to all the blends and diesel.
- The formation of nitrogen oxide emissions depends on the heat transfer rate and evaporation rate of the fuel. This increases further, with the availability of oxygen and the higher prevailing temperatures in the chamber. With the ceramic coating the heat in the chamber is higher which further increases the evaporation rate of the fuel. Blend B20 gives NO_x emission 584ppm which is higher when compared to all the blends and diesel.

VII.SCOPE OF FUTURE WORK

The present work can be extended by varying the thickness of thermal barrier coating on piston crown. The engine can be tested for better performance with various alternative fuels also.

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