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# EFFECTS OF TITANIUM OXIDE COATING ON CI ENGINE USING FLAXSEED OIL-DIESEL BLENDS

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***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. Ceramic coatings like Titanium Oxide 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 flaxseed oil using Titanium oxide coated piston on a four stroke single cylinder water cooled diesel engine test rig. Experiments were carried out on a diesel engine using different blends of flaxseed oil 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 indicates that the piston which is coated with $TiO_2$using flaxseed oil blends gives better performance and emission results compared to all fuel mixtures and diesel under this study.**

**Keywords**: Flax Seed Oil, Titanium Oxide, single cylinder 4-stroke diesel engine, Engine performance.

## I.INTRODUCTION

Majority of the world's energy needs are supplied through Petrochemical sources, coal and natural gases, with the exception of hydroelectricity and nuclear energy; of all, these sources are finite and at current usage rates will be consumed shortly. Diesel fuels have an essential function in the industrial economy of developing countries and are used for transport of industrial and agricultural goods, operation of diesel tractor and pump sets in agricultural sector. The high energy demand in the industrialized world as well as in the domestic sector and pollution problems caused due to the widespread use of fossil fuels make it increasingly necessary to develop the renewable energy sources of limitless duration and smaller environmental impact than the traditional one. This has stimulated recent interest in alternative sources for petroleum based fuels. Because alternate fuels 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.

**Biodiesel** is a clean burning fuel, which means that it does not give off harmful emissions that cause environmental effects. Since bio-diesel is oxygenated, diesel engines have more complete combustion with bio-diesel than with petroleum. Biodiesel is safer to use than petroleum diesel. The use of biodiesel in a conventional diesel engine results substantial reduction of un-burnt hydrocarbons, carbon monoxide, and particulate matter.

Ceramic coatings used in 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. When increased exhaust gases temperatures considered, it is obvious that turbocharging and consequently total thermal efficiency of the engine is increased.

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II.LITERATURE REVIEW

*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. 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. 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 M.J* [2] has studied the high temperature and pressure produced in an engine that uses compressed natural gas with direct injection system (CNGDI) which 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.

*H. Hazar, U. Ozturk* [3]studied the effect of $Al_2O_3$-$TiO_2$ coating in a diesel engine on performance and emission of corn oil methyl ester, the piston, cylinder head, exhaust and inlet valves of a diesel engine were coated with the ceramic material $Al_2O_3$-$TiO_2$ by the plasma spray method. Thus, a thermal barrier was provided for the parts of the combustion chamber with these coatings. The effects of corn oil methyl ester that produced by the trans esterification method and ASTM No. D2 fuels performance and exhaust emissions' rates were studied by using equal in every respect coated and uncoated engines. Tests were performed on the uncoated engine, and then repeated on the coated engine and the results were compared. A decrease in engine power and specific fuel consumption, as well as significant improvements in exhaust gas emissions (except NOx), were observed for all test fuels used in the coated engine compared with that of the uncoated engine.

III. FLAX SEEDOIL

Fig.1: Flaxseed Plant

Flaxseed oil scientific name is Linum usitatissimum, (or) Linaceae. The yellowish oil is derived from dried ripe seeds of flax plant through pressing and extraction. It is available in varieties such as cold Pressed, alkali refined, sun Bleached, sun thickened, and polymerized (stand oil) marketed as flaxseed oil. Flaxseed oil is the most commonly used carrier in oil paint. Several coats of flaxseed oil acts as the traditional protective coating for the raw willow of a cricket bat. Fresh, refrigerated and unprocessed, flaxseed oil is used as nutritional supplement. It is available in Asian countries.

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, titanium oxide ($TiO_2$)wascoated on piston crownand flax 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.

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Fig.2 Titanium Oxide Coated Piston

TABLE 1
TEST ENGINE SPECIFICATIONS

| Particulars | Specifications |
|---|---|
| Make | Kirloskar oil Engine Ltd. |
| Arrangement of cylinders | Vertical |
| No of cylinders | 1 |
| Lubricant | SAE 20/SAE40 |
| Bore | 85mm |
| Stroke length | 110mm |
| Rated speed | 1500 rpm |
| Rated power | 5HP |
| Starting | Hand start with crank handling |
| Type of cooling | Water cooling |

## V. RESULTS AND DISCUSSIONS

### *A.Brake Specific Fuel Consumption:*

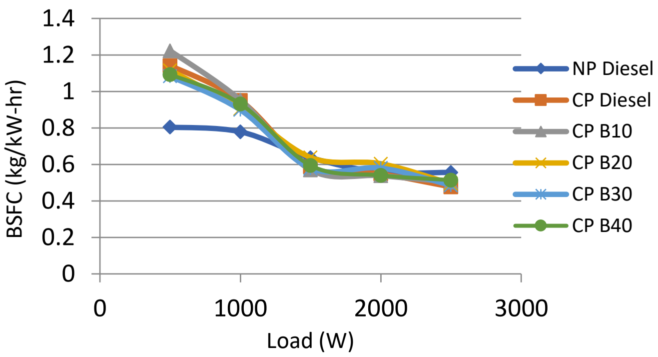


Fig.3Load vs Brake Specific Fuel Consumption

The result for the variations in the brake specific fuel consumption (BSFC) with load is presented in the Fig.3. From fig.3 it can be clearly seen that the BSFC of $TiO_2$ 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 0.556 kg/kW-hr for diesel (standard engine), 0.477 kg/kW-hr for diesel ($TiO_2$ coated piston) and 0.503, 0.495, 0.486, 0.514 kg/kW-hr for the flaxseed oil blends respectively.

### *B.Brake Thermal Efficiency:*

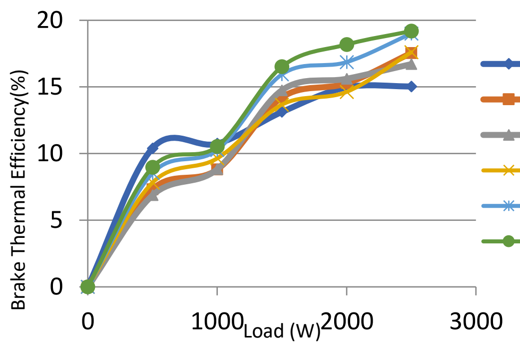


Fig.4 Load vs Brake Thermal Efficiency

The variation of brake thermal efficiency with respect to load for flaxseed oil blends and diesel are shown in Fig.4. It can be observed from the results that the $TiO_2$ 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.

### *C.Exhaust Gas Emissions of Carbon Monoxide*

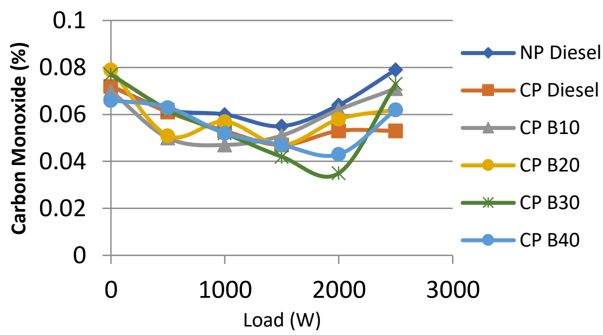


Fig.5 Load vs Carbon Monoxide

From Fig.5 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,

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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 emissions of standard engine (diesel) slightly higher than $TiO_2$ coated piston engine at full load condition. Carbon monoxide from the exhaust gas for the diesel fuel (standard engine) is 0.079% by vol. and for $TiO_2$ coated piston engine using blends B0, B10, B20, B30 and B40 are 0.053, 0.071, 0.062, 0.073, and 0.062% by vol. respectively at full load.

*D. Exhaust Gas Emissions of Carbon Dioxide:*

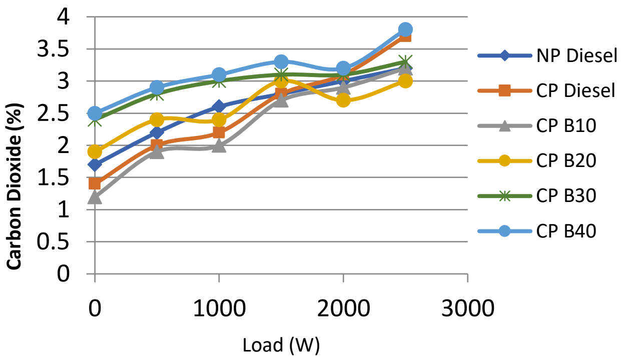


Fig.6 Load vs Carbon Dioxide

As shown in Fig.6, the variation of carbon dioxide emissions with respect to load can be observed. From the results, it is observed that the amount of $CO_2$ produced while using flaxseed 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 3.2% vol. and for $TiO_2$ coated piston engine for different blends of flaxseed oil are 3.7, 3.2, 3, 3.3 and 3.8% by vol. respectively. As a general rule, the higher the carbon dioxide reading, the more efficient the engine is operating.

*E. Unburnt Hydrocarbon Emissions*

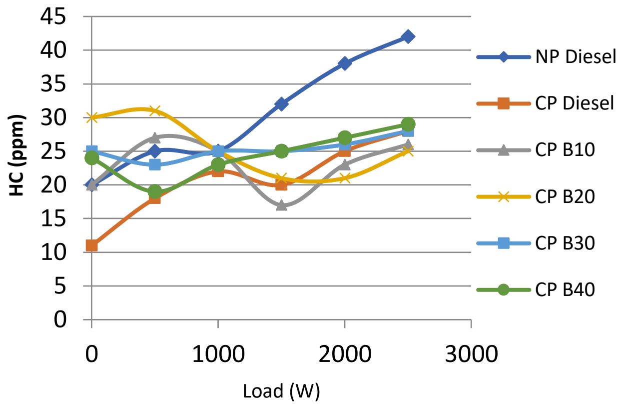


Fig.7 Load vs Hydro Carbons

The variation of hydrocarbons with respect to load for tested fuels is depicted in Fig.7. From the results, it can be noticed that the concentration of hydrocarbon of flaxseed blends is slightly lower than diesel. Unburnt hydrocarbon from the exhaust gas at full load for the diesel fuel (standard engine) is 42ppm and for coated piston engines using flaxseed oil blends B0, B10, B20, B30, B40 are 28ppm, 26ppm 25ppm, 28ppm, and 29ppm respectively. It can be observed from the results that thermal barrier coating ($TiO_2$) 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.

*F. Exhaust Emissions of Nitrogen Oxides*

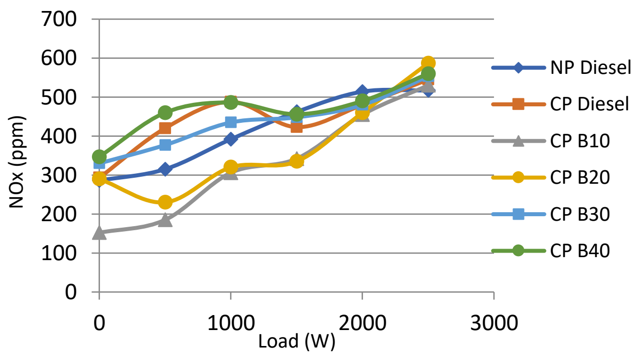


Fig.8 Load vs Nitrogen Oxides

From Fig.8, 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. With the ceramic coating the heat in the chamber is higher which further increases the evaporation rate of the fuel.

## VI.CONCLUSIONS

Performance and emission characteristics of diesel (C.I) engine with blends of biodiesel of flax seed oil with diesel and Titanium oxide as piston coating are compared with the normal diesel engine in this experimental investigation. From this investigation, it can be concluded that flaxseed blends with $TiO_2$ as piston coating 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 Titanium oxide using flax seed oil blends as compared to the normal engine with diesel at all load conditions.
- Brake Thermal efficiency of the tested diesel engine is improved when it is fuelled with flaxseed oil-diesel blends operating on $TiO_2$ coated piston [9].
- CO emissions of biodiesel are less compared to diesel; it is likely due to oxygen content present in the biodiesel.
- It is observed that the amount of $CO_2$ produced while using flaxseed oil blends are higher than diesel at full load condition, this indicates the complete combustion of fuel [10].
- It can be observed from the results that thermal barrier coating ($TiO_2$) in piston crown decreasing HC when compared with uncoated piston 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.
- 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.

## VII. SCOPEOF 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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REFERENCES

[1]. AydinHuseyin examined the "Combined effects of thermal barrier coating and blending with diesel fuel on usability of vegetable oils in diesel engines "*Applied Thermal Engineering 51(2013) 623e629*.

[2].HelmisyahA.J.,Ghazali M.J "Characterization of Thermal barrier coating on piston crown for compressed natural gas direct injection (CNGDI) engines*" AIJSTPME (2012) 5(4):73-77.*

[3]. H. Hazar, U.Ozturk "The effect of $Al_2O_3$-$TiO_2$ coating in a diesel engine on performance and emission of corn oil methyl ester "*Renewable Energy 35 (2010) 2211e2216.*

[4]. T. Karthikeya Sharma "Performance and emission characteristics of the thermal barrier coated SI engine by adding argon inert gas to intake mixture "*Journal of Advanced Research (2014).*

[5]. Vinay Kumar.D, Ravi Kumar.P, M.SantoshaKumari "Prediction of Performance and emissions of a biodiesel fueled Lanthanum Zirconate coated direct injection diesel engine using Artificial Neural Networks"*Procedia Engineering 64 (2013) 993 – 1002.*

[6]. John B.Heywood, "Internal Combustion Engine fundamentals", *McGraw-Hill Series in Mechanical Engineering*.

[7].Uzun, A.,Çevik, İ. &Akçil, M. (1999), "Effects of Thermal barrier coating on a Turbocharged diesel engine performance", *Surface and Coating Technologies 16-119, 505-507*

[8]. V.Ganesan, "Internal Combustion Engines", *Tata McGraw-Hill Publishing Company Limited.*

[9] Kotla, P. (2023). Adaptive Learning in UiPath: Enhancing RPA for Continuous Improvement and Scalability Author Name: Praneetha Kotla Role: Lead Robotics Process Automation Developer. Available at SSRN 5315673.

[10] Kotla, P. (2024). Task Mining as a Catalyst for Automation: Realizing Process Improvement with Uipath in Healthcare Scheduling.