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# Effect of Titanium Oxide Coating on Performance Characteristics of Bio-Diesel (Honge) Fuelled C.I.Engine

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***Abstract:*** *This paper presents the effect of Titanium oxide coating on the performance characteristics of the bio-diesel fuelled engine. The engine used was four strokes, single cylinder direct injected diesel engine. The engine was tested with diesel & at different proportionality of diesel with Honge bio-diesel and by varying torque without coating. Then, the piston head was coated with thermal barrier material. The layer of thermal coating was made of Alumina-Titanium oxide ($Al_2O_3/TiO_2$) plasma coated on to the base of NiCrAl. Then the coated piston was tested at the same operation conditions as the standard (without coating) engine. The results indicate a reduction in specific fuel consumption and an improved brake thermal efficiency for titanium oxide coated piston.*

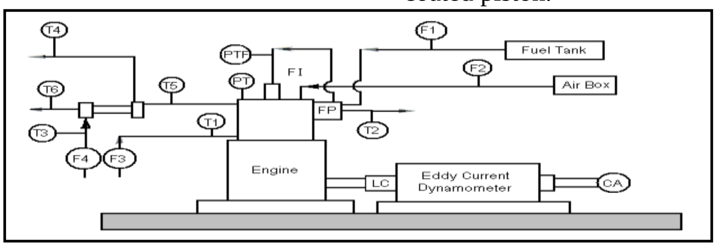
***Keywords-*** *Bio-diesel, Performance characteristics, Thermal barrier coating, Titanium Oxide*

## I. INTRODUCTION

Thermal barrier coatings have been apply to the internal combustion engine in particular the combustion chamber and cylinder lands to act as a low heat rejection engine, heat engine is improvement of their thermal efficiency. One of the methods to an engine is to cover the surface of the combustion chamber with a thermal barrier coatings, the thermal insulation obtained leads to an development of engines heat efficiency and a reduction in consumption. High temperature in the combustion can have a positive effect in diesel engines due to reduction in delay and hardness of engine operation, all though an increasing the emission of $NO_x$.

The resources of petroleum as fuel are dwindling day by day and increasing demand of fuels, as well as increasingly stringent regulations, pose a challenge to science and technology. With the commercialization of bioenergy (bio-diesel), it has provided an effective way to fight against the problem of petroleum scarce and the influence on environment. Bio-diesel can be used in diesel engine with little or no modification in the engine [1]. The properties of bio-diesels are not same as diesel as it is having high viscosity, high volatility and Low cetane number [2]. In order to improve the combustion, there should be minimum heat loss from the combustion chamber. Minimum heat loss can be achieved by coating thermally insulated materials to the surfaces of combustion chamber. Mohd.F.Shabir, P. Tamilporai, and B. Rajendra Prasath used low heat rejection engine by coating the piston crown, cylinder head inside with valves and cylinder liner with partially stabilized zirconia coating of 0.5 mm thickness [3]. Imdat Taymaz used thermally insulated material such as $CaZrO_3$ and $MgZrO_3$ for insulation of different surfaces of combustion chamber. An improvement of efficiency of 2-5% was observed [4]. Abdullah Uzun used $CaZrO_3$ on cylinder head and valves and $MgZrO_3$ on piston. Thermal efficiency was improved by 10% and reduction of CO emission was 35 to 40% [5].

The purpose of this study is to evaluate the brake thermal efficiency and brake specific fuel consumption at different loads with and without thermal barrier coating. The experiments were conducted with a single cylinder, four stroke and direct injected diesel engine. The results showed an increase in brake thermal efficiency, decrease in brake specific fuel consumption for titanium oxide coated piston.




**PTF : Fuel Injection Pressure Sensor**
**T5 : Exhaust Gas Temperature before Calorimeter**
**F2 : Air Flow Rate**
**T6 : Exhaust Gas Temperature after Calorimeter**
**PT : Combustion Chamber Pressure Sensor**
**F1 : Liquid fuel flow rate**
**FI : Fuel Injector**
**F3 : Jacket water flow rate**
**FP : Fuel Pump**
**F4 : Calorimeter water flow rate**
**T1 : Jacket Water Inlet Temperature**
**LC : Load Cell**
**T2 : Jacket Water Outlet Temperature**
**CA : Crank Angle Encoder**

**T3 : Inlet Water Temperature at Calorimeter** **EGC: Exhaust Gas Calorimeter**
**T4 : Outlet Water Temperature at Calorimeter**

FIG 1: Schematic diagram of experimental set up

## II. EXPERIMENTAL WORK

A four stroke, direct injected single cylinder diesel engine was used for experimentation (Table 1). The schematic experimental set up is shown in Fig 1. Engine torque was measured by eddy current dynamometer. The engine has a conventional fuel injection system. A piezoelectric pressure transducer was mounted with cylinder head surface to measure the in cylinder pressure. It is also provided with temperature sensors for the measurement of jacket water, calorimeter water, and calorimeter exhaust gas inlet and outlet temperatures. An encoder is fixed for crank angle record. The signals from these sensors are interfaced with a computer to an engine indicator to display P-Ө, P-V, mass fraction burnt and heat release versus crank angle plots. The provision is also made for the measurement of volumetric fuel flow. The built in program in the system calculates indicated power, brake power, thermal efficiency, volumetric efficiency and heat balance. The software package is fully configurable and averaged P-Ө diagram, P-V plot and other diagram can be obtained for various operating conditions.

First, standard piston (without coating) was tested. The tests were performed at different loads and for diesel and different proportionality of diesel with Honge bio-diesel (i.e. B10, B20 and B30) for a compression ratio of 17.5:1 and injection pressure of 200 bar.

Then the Piston head was coated with thermal barrier material. The piston head was coated with a 150µm Alumina-Titanium oxide ($Al2O_3/TiO_2$) plasma coated on to the base of 60µm NiCrAl. Then the coated piston was tested at the same operation conditions as the standard (without coating) piston.

TABLE 1: ENGINE SPECIFICATION

| SL NO | ENGINE PARAMETERS | SPECIFICTION |
|---|---|---|
| 01 | Engine Type | TV1(Kirloskar) |
| 02 | Number of cylinders | Single Cylinder |
| 03 | Number of strokes | Four-Stroke |
| 04 | Rated power | 5.2KW (7 HP) @1500RPM |
| 05 | Bore | 87.5mm |
| 06 | Stroke | 110mm |
| 07 | Cubic Capacity | 661cc |
| 08 | Compression ratio | 17.5:1 |
| 09 | Rated Speed | 1500 RPM |

## III. RESULTS AND DISCUSSION

### 3.1Brake thermal efficiency:

The comparison charts for brake thermal efficiency with respect to brake power for coated piston and base piston for diesel and various biodiesel blends are plotted as shown in figures 2 to 5.

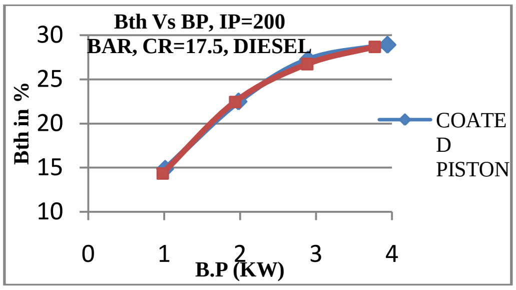



FIG 2: Bth Vs B.P for Diesel

Fig 2 shows the variation of Bth with Brake power for Diesel for coated piston and base piston. We can see that as the load increases the Bth also increases. In the above fig we don't find much difference only a slight increase in the Bth for the coated piston. This is because of the titanium oxide which acts as catalyst to enhance the combustion and also due to the thermal barrier coating which heat transfer. And hence the Bth of the coated piston is better than base piston.

Fig 3 shows the variation of Bth with Brake power for H10 (i.e. 10% Honge+ 90% Diesel) for coated piston and base piston. We can observe from the graph that the Bth of the coated piston if high when compared to standard piston. Maximum efficiency was found to be around 27% at high load for coated piston.

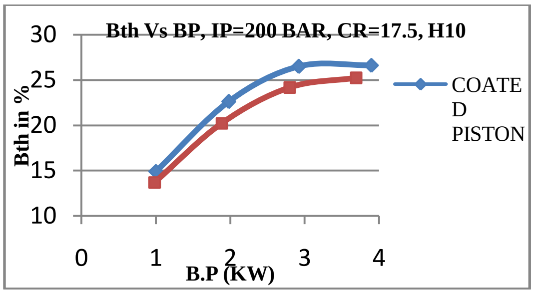



FIG 3: Bth Vs B.P for H10

Fig 4 shows the variation of Bth with Brake power for H20 (i.e. 20% Honge + 80% Diesel) for coated piston and base piston. From the graph we can see that the Brake thermal efficiency of the coated piston is high. Maximum efficiency was found to be around 28% at high load for coated piston.

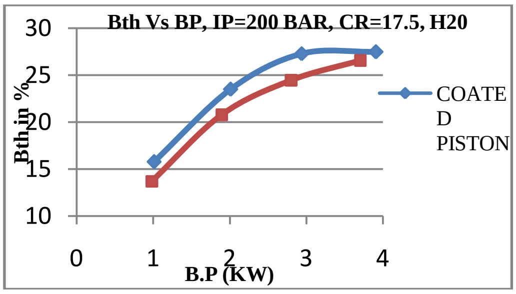



FIG 4: Bth Vs B.P for H20

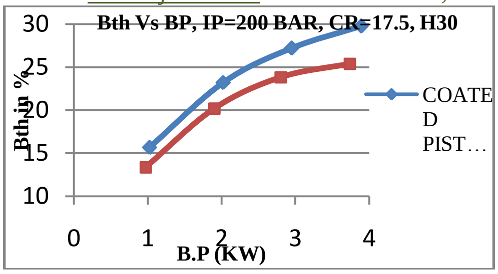



FIG 5: Bth Vs B.P for H30

Fig 5 shows the variation of Bth Vs B.P for H30 (i.e. 30% Honge+70% Diesel) for coated piston and base piston. In fig 5 we can see that the Bth for coated piston is high.

FIG 2 to 5 shows the variation of Brake thermal efficiency with Brake Power for Diesel, H10, H20 and H30 for coated piston and base piston. It is observed from all the above graphs that the Bth for coated piston for all fuels is high. This may be due to the high temperature in the combustion chamber due to the thermal resistance of the coated piston where heat loss is minimal. It may be also because of percentage of titanium oxide which acts as catalyst to enhance the combustion and hence efficiency of coated piston is high for all the fuels.

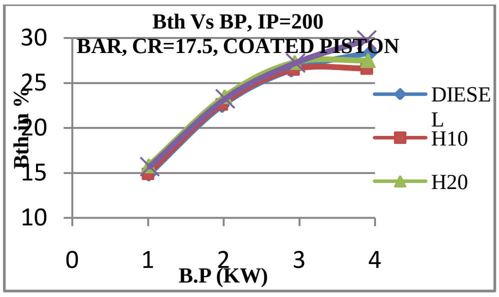



FIG 6: Bth Vs BP for Coated Piston

Fig 6 shows the variation of the Bth with Brake Power for coated piston for different fuels. It is observed from the graph that we don't find much difference only slight variation in the Bth for H30 than the other biodiesel blends and pure diesel. Only at high loads we can find the clear difference. This is because of the increased oxygen content in H30 fuel which accounts for better combustion and also due to decrease in fuel consumption. It may be also because of high temperature reached in combustion chamber due to minimal heat loss which accounts for better combustion.

### 3.2 Brake Specific Fuel Consumption:

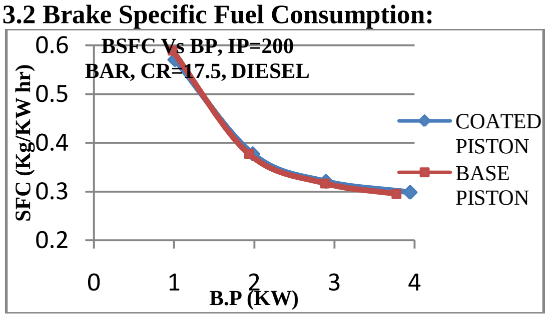



FIG 7: BSFC Vs BP for Diesel

Fig 7 shows the graph of B.S.F.C Vs B.P for coated pistons and base piston for Diesel fuel. In the graph we don't find much difference between the SFC of coated piston and base piston for diesel.

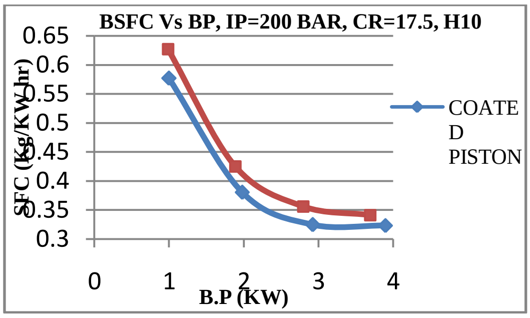



FIG 8: BSFC Vs BP for H10

Fig 8 shows the graph of B.S.F.C Vs B.P for coated piston and base piston for H10 fuel. In the graph we can see that the SFC for coated piston is low when compared to base piston.

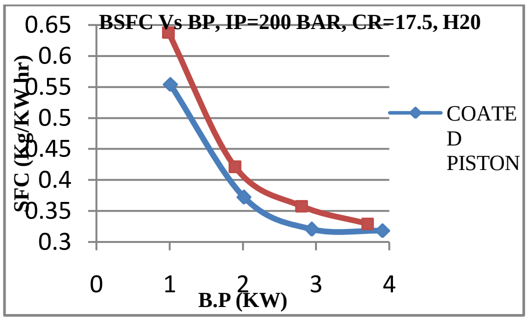



FIG 9: BSFC Vs BP for H20

Fig 9 shows the graph of B.S.F.C Vs B.P for coated pistons and base piston for H20 fuel. In the graph we observe that the SFC for coated piston is less than that of the base piston.

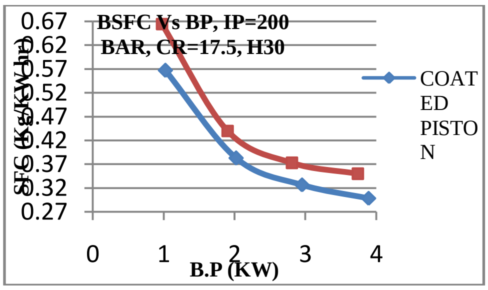



FIG 10: BSFC Vs BP for H30

Fig 10 shows the graph of B.S.F.C Vs B.P for coated piston and base piston for H30 fuel. In the graph we see that the SFC for coated piston is low than the base piston.

FIG 7 to 10 shows the variation of Brake specific fuel consumption with Brake Power for Diesel, H10, H20 and H30. We can observe from the above graphs that the S.F.C for coated piston for all the fuels is low when compared to base piston. This is because of better combustion of the fuel due to high temperature in combustion chamber because of thermal resistant due to the coated material and also due to composition of titanium oxide which acts as catalyst to enhance combustion and thus reduces the fuel consumption for titanium oxide coated piston.

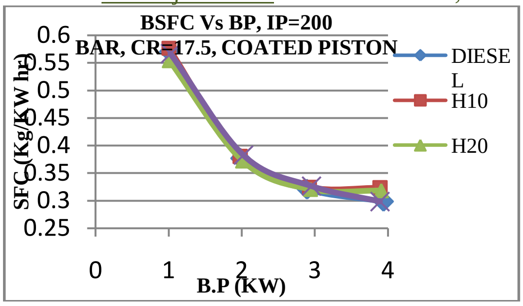



FIG 11: BSFC Vs BP for Coated Piston

Fig 11 shows the variation of B.S.F.C with B.P for coated piston for different fuels. We can't find much difference only a slight variation can be observed from the graph that the S.F.C for H20 gives good result but at high load H30 gives good result for coated piston.

## IV. Conclusion

Experimental investigations of the effect of the titanium oxide coating on performance characteristics was conducted on single cylinder, 4 stroke, direct injected, constant speed diesel engine. Tests were conducted for the base piston and coated piston for different loads and compression ratio of 17.5 and injection pressure of 200 bar. The major conclusions drawn from these experiments are as follows:

1. The Brake thermal efficiency of the coated piston is increased when compared to base piston. Also biodiesel H30 giving higher thermal efficiency when compared to other biodiesel blends and pure diesel.
2. The Specific fuel consumption is lower for the coated piston when compared to base piston. Biodiesel blend H30 at high loads and blend H20 giving better results at low loads.

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