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Effect Of Zirconium Coated Piston On The Performance Of The Ciengine Fuelled With Dies El And Bio- Diesel Blends

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ABSTRACT

In this work an attempt was made to evaluate the effect of catalytic coated piston onthe performance characteristics of a standard direct injection compression ignition engine. Zirconium Oxide(Zr O2) was used as a coating material and the same was coated for a thickness of 400μm on the piston head. Diesel and bio diesel blends were used as test fuels in this investigation. Bio diesel blends were prepared by mixing bio diesel and diesel on volume basis It was observed that with the coated piston, engine performance was increased significantly. The increase in brake thermal efficiency (BTE) was observed at all loads for diesel fuel and only at higher loads for bio diesel blends. Among the bio diesel blends B5(5% bio diesel + 95% diesel on volume basis) increases BTE at all loads due to the thermal barrier coating.

Key words. I.C. engine, TBC, BTE, Zirconium, Bio diesel, LHR, Performance

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1.INTRODUCTION:

Diesel engine plays a dominant role in the agriculture, transport and industrial sector of all the countries due to its higher efficiency than that of petrol engine. Even though its efficiency is higher, the maximum possible efficiency falls between 30 to 40%. Apart from the various losses, heat taken away by cooling water , through combustion chamber walls contribute a significant percentage to the total heat losses. As per the second law of thermodynamics, by minimizing heat rejection rate, the efficiency of the engine can be improved. Low heat rejection, which is called, as semi- adiabatic engine is one such concept developed to reduce the heat loses through the combustion chamber walls. In this method heat developed during combustion was restricted to flow through combustion chamber wall. By this method the heat available in the combustion chamber to convert it into mechanical work gets increased which may increase the power output of the engine.

Earlier investigations have reported that the overall thermal efficiency of a low heat rejection engine was lower or higher than standard engine (un insulated) depends upon the test conditions and method used (Brayil WR et al 1983; Toyama K.Yoshimitsu et al 1983; Woschni G.sprindler et al 1987). From Dickeys (1989) investigation, the thermal efficiency of LHR engine is lower than that of standard engine, because of lower compression ratio and degraded combustion. Kamo et al (1999) conducted an experiment to test whether a thin layer thermal barrier coated (TBC) engine could improve its performance when high-pressure injector was used. He found that TBC engine had higher thermal efficiency by 5-6% compared to standard engine. Ekrem Buyukkaya et al (2006) investigated, the effect of thermal barrier coating on gas emissions and performance of a LHR engine with different injection timing. In his investigation he concluded that TBC engine had 1-8% reduced specific fuel consumption and this could be by combined effect of TBC and injection timing.

He also reported that Nox emissions were reduced by 11-18% when compared with standard engine. Earlier investigations on the LHR engine were conducted with diesel fuel and less attempt was made to test the LHR engine with bio fuels.

In the present energy scenario, bio fuel will be a promising fuel to replace diesel fuel either fully or partially. Several investigations were conducted on methyl ester of vegetable oil called bio diesel to examine its ability to replace diesel oil (T.W Rayn et al 1980; J.R.Needham et al 1985; M.Ziwjwqaki et al 1986). It was reported that bio diesel has an ability to replace diesel fuel either fully or partially with out any modification in the existing engine system (Dilip kumar Bora .L et al 2008). It was also reported that employing bio diesel in blended form has minimized the demerits of utilizing bio diesel in its pure form. (Rao GLN et al 2007; Rao GLN et al 2008)

The main objective of this present investigation is to develop a LHR engine and to test the same with diesel and bio diesel blends,

An experiment was conducted to study the effect of TBC on the performance of diesel a engine. The test has been carried out on a single cylinder diesel engine for various mixture of bio diesel blends and results were compared with diesel fuel.

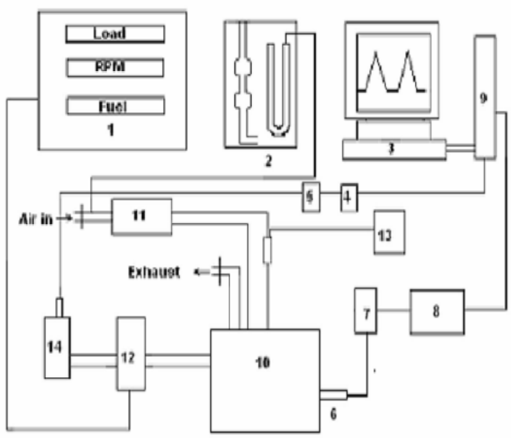
2. TEST ENGINE AND FUEL:

A single cylinder direct injection diesel engine was used for the present work. The standard piston of the engine was removed and Zirconium oxide (Zr O2) was coated on the piston head as a thermal barrier coating by plasma spray process for the thickness of 400µm. Zirconia a ceramic material has a very low thermal conductivity values, good strength, thermal expansion coefficients similar to metals and is able to withstand much higher temperature than metals. (S.Jaichandar et al 2003).

As the result of fitting this coated piston the standard engine may be called as LHR engine and experiments were conducted on it with test fuels. Methyl ester derived from sunflower oil was taken as bio diesel for the present investigation.

3. EXPERIMENTAL PROGRAMME:

Figure 1 shows the experimental set up and table 1 shows the specification of the engine. The engine is coupled with an air cooled eddy current dynamometer to load the engine.



1. Control panel
2. Fuel flow measuring unit
3. Computer system
4. DAQ
5. Power supply
6. Crank angle encoder
7. Charge amplifier
8. Pressure pick up
9. Terminal Board
10. Engine
11. Air tank
12. Dynamometer
13. CDM unit system
14. PC Virtual instrumentation

Figure 1 Layout of experimental set up

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Type	4 stroke 1 cylinder water cooled self start diesel engine
Rated power	5.2 kW
Compression ratio	17.5:1
Bore x Stroke (mm)	87.5 x 110
Cubic capacity	662
Rated speed (rpm)	1500
Connecting Rod length(mm)	234
Orifice diameter (mm)	20

Table 1 Specification of the engine

3.1 TESTING PROCEDURE:

Testing was carried at rated speed of the engine. In addition to diesel fuel four more test fuels were prepared by blending bio diesel and diesel in volume basis. Percentage of bio diesel in the blend was varied from 5-20% in steps of 5 to obtain the test fuels of B5, (5%bio diesel + 95% diesel) B10, B15, B20. First the engine testing was conducted on the standard engine. At various loads fuel consumption rate was measured when the engine was running with test fuels as before.

Now the standard engine (SE) is converted in to coated engine (CE) by replacing the standard piston with Zirconium oxide coated piston. Testing were conducted on this CE with test fuels.

4. RESULTS AND DISCUSSION:

In this chapter the brake thermal efficiency (BTE) of the engine was discussed for SE and CE when the engine was running with test fuels. Effect of coating on brake thermal efficiency for the test fuels was given by comparing it with SE of diesel.

Figure 2 compares the variation of BTE with load for coated engine when the engine was fuelled with B5 and it was compared with SE operation with B5 and diesel fuel. It was observed that by blending 5% of methyl ester with diesel produces a marginal increase in BTE at higher loads and a decrease in efficiency of 10% at lighter loads, when compared with SE operation with diesel fuel. This may be due to that at lighter loads the temperature exists in the combustion chamber was not enough to burn the methyl ester present in the blend since the burning temperature of methyl ester is higher than diesel. At higher loads the temperature will be high which burns the methyl ester present in the blend and also the oxygen present in the methyl ester improves the combustion process, which results in an higher BTE than that of the SE with diesel fuel. It can be seen that as a result of coating the BTE of SE was increased by 38.59% when the engine was fuelled with B5. This is due to the reduction of the heat losses through combustion chamber walls.

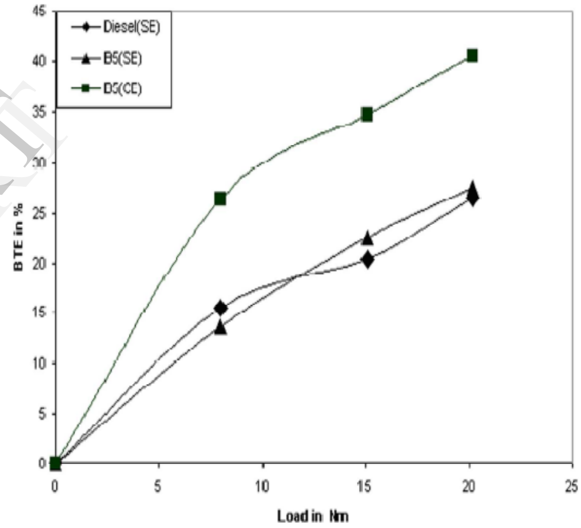

Figure 2 Variation of BTE with load in SE & CE for B5

Variation of brake thermal efficiency with load for the SE with diesel fuel & B10 and CE with B10 is shown in figure 3. It shows that SE with B10 has 53.8 % higher efficiency than that of SE with diesel. Oxygen present in the methyl ester improves the combustion process, which results a higher BTE than that of SE with diesel. It was also observed that CE with B10 has 20% lower efficiency at lighter loads and 6% higher efficiency at higher load than that of its SE. When compared with SE with diesel, BTE of CE was 39.8% higher for the blend B10.

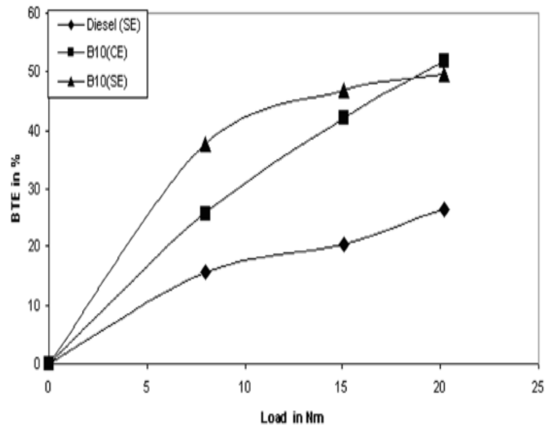

Figure 3 Variation of BTE with load in SE & CE for B10

Figure 4 shows the variation of BTE with load for CE when the engine was fuelled with B15 and it was compared with SE with diesel and B15. It was observed that SE with B15 has 39.8% higher efficiency than that of SE with diesel. . It was also observed that as a result of coating, BTE was decreased at all loads when the engine was fuelled with B15. BTE of CE with B15 was 36.59% higher than that of the SE with diesel.

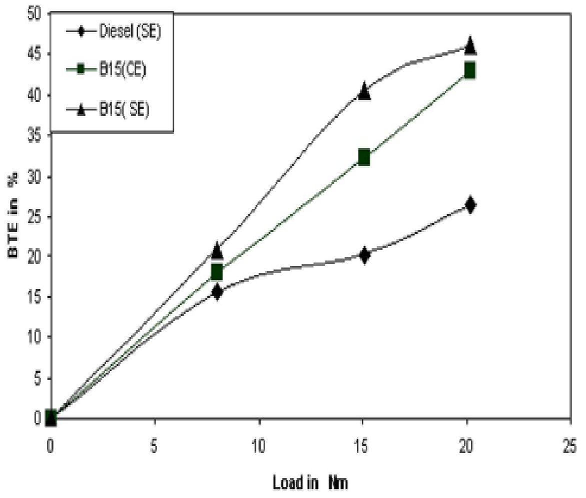

Figure 4 Variation of BTE with load in SE & CE for B15

Figure 5 compares the variation of BTE with load for coated engine when the engine was fuelled with B20 and this was compared with SE operation with B20 and diesel. It was observed that during standard operating conditions the BTE with B20 was 42.6% higher than that of diesel. As a result of coating the B20 shows an increase in BTE of 21.3% at higher load and decrease in BTE of 31.9% at lighter loads. When compared with SE with diesel, CE with B20 records 44.9% higher BTE at higher loads.

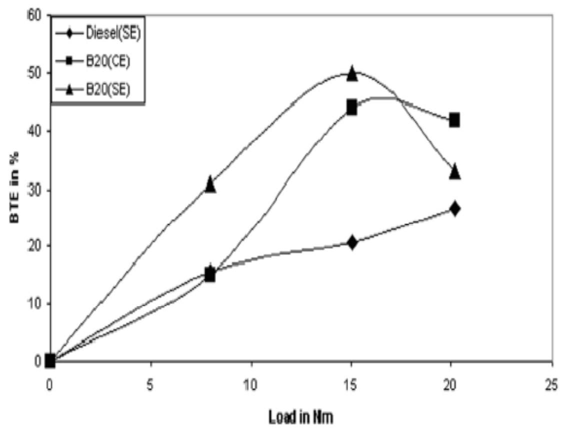

Figure 5 Variation of BTE with load in SE & CE for B20

5. CONCLUSION:

This investigation compared the effect of Thermal Barrier Coating (TBC) on the piston in the performance characteristics of the engine when it was fuelled with diesel and bio diesel blends. It can be observed that as a result of TBC, BTE of the engine was increased significantly. This increase in BTE was recorded at all loads for diesel and only at higher load for bio diesel blends. Among the blends of bio diesel, B5 records higher BTE for coated engine at all loads.

From the experimental investigation it can be concluded that it is possible to increase the engine efficiency through TBC. This investigation can be extended to increase BTE at all loads for bio diesel blend operations.

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