Int. J. Chem. Sci.: 14(1), 2016, 152-160
ISSN 0972-768X
www.sadgurupublications.com

EXPERIMENTAL INVESTIGATION ON ENGINE PERFORMANCE AND EMISSION IN DIESEL ENGINE BY ALUMINIUM-TITANIUM THERMAL BARRIER COATING

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ABSTRACT

Various types of thermal barrier coating have been carried out in order to improve the efficiency of the engine. In this paper, variation in the coating thickness has been discussed with conventional coating materials, aluminium-titanium and their effect in the performance of the engine is studied. Aluminium possessing low thermal conductivity and lower material density suits idler to TBC. Titanium known for its high temperature with standability offers the thermal stability to the coating material. To increase the efficiency and to overcome the heat loss in the IC engine by coating the low thermal conductivity material in the engine combustion chamber. Here, we differ the coating thickness of the TBC material in the combustion chamber and compare the performance of the IC engine.

In the internal combustion diesel engine efficiency range is about 38-42%. It means about 60% of the fuel energy is wasted in form of heat energy to the atmosphere. For reducing this energy loss, combustion chamber components are coated with low thermal conductivity material. This paper makes a study of performance of diesel engine with different thickness of thermal barrier coating TBC on IC engine. Here, we select aluminium titanium are the low thermal conductivity material used as the TBC in IC engine. The low thermal conductivity material are coated in the piston top, inlet & exhaust valve and cylinder head at two level of thickness of TBC and compare the performance and emission of the IC diesel engine

Key words: Aluminium-titanium, Performance, Emission, Diesel engine.

INTRODUCTION

In the internal combustion diesel engine thermal efficiency is mainly depends on the temperature in the combustion chamber.[9] The temperature of the combustion chamber is

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increase the thermal efficiency will automatically increase.[7,8] To reduce the heat loss in the combustion chamber, low thermal conductivity material is used to coated in the combustion chamber like cylinder head, inlet & exhaust valves and piston top[1,2]. This will reduce the heat loss from the combustion chamber to the surrounding. On other hand the engine will become Low Heat Rejection (LHR) engine. The combustion chamber temperature will be increased because of arresting the heat transfer from the engine to the surrounding[3].

In this project, the aluminium-titanium Al-Ti was selected as the thermal barrier coating TBC is coated in the piston top, inlet & exhaust vales and cylinder head.[4,16] The method of coating the thermal barrier material is plasma spray technique and evaluates the performance changes according to the thickness level of TBC in the engine[5,6] and also discuss about the emission[13]. Later on the TBC thickness level is changed and evaluated the performance and emission of the LHR diesel engine.

In the project, we get a clear view about the TBC thickness level various and their performance and emission evaluation various.[17] The various level of performance different in the varying the level of TBC thickness. The tentative range thickness of TBC is 0.5 mm and 1 mm in the engine.[10,11] The final result will be the comparatively study of performance and emission of IC diesel engine.

Finally, the readings were noted brake power, specific fuel consumption, hydrocarbon, oxides of nitrogen, carbon monoxide. These results are evaluated in the graphs manner. They are Study state condition, 0.5 mm TBC & 1 mm TBC.

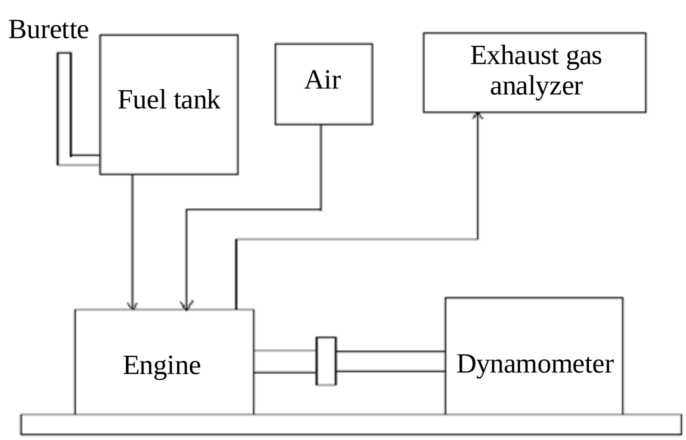

Fig. 1: Engine set up

Table 1: Engine specification

Engine model	Kirloskar TV1 engine
Engine type	Vertical, four stroke
Fuel used	Diesel
Bore diameter	80 mm
Stroke length	110 mm
Brake power	3.728 KW
Compression ratio	16 : 1
Speed	1500 RPM
Injection type	Direct injection
Cooling	WATER
Engine power	5 bhp
No of cylinder	1
Injection pressure	210 bar
Specific gravity of fuel	0.8275
Calorific value	42000 Kj/Kg

Plasma spray technique

A high temperature plasma stream is created by non-transferred plasma arc within the torch. Many gases may be ionized this way, argon or nitrogen with small additions of hydrogen and helium are popular choices.[12,15]

In an ionized gas, free electrons have been stripped from the atoms and recombination releases very significant thermal energy. The plasma stream can reach temperatures of 10,000-50,000 degrees Fahrenheit.

The sizes of the aluminium-titanium are less than 10 microns. Due to the high temperature the barrier materials are deposited in the engine materials with high bond. This bond is not affected by the operating temperature and pressure inside the combustion chamber of the IC diesel engine.

The arrangements of the plasma spray coating method are shown in the Fig. 2. Plasma gas is passed between the anode and cathode the high temperature flame will be produced. The powered form of aluminium-titanium is passed in the flame the powder material are coated in the working surface with high bonding

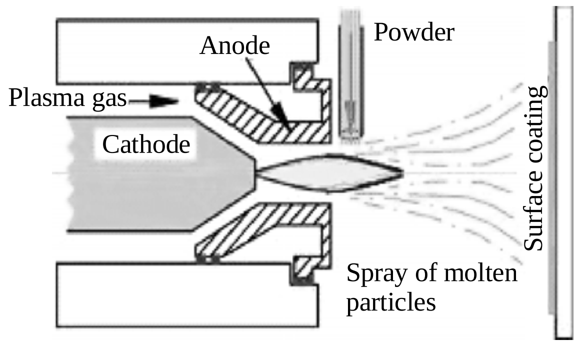

Fig. 2: Plasma spray technique

Total fuel comsumption

The total fuel consumption values are obtained from the formula. This means after coating the engine the TFC is considerably reduced. The different between of the TBC thickness the range of engine total fuel consumption are shown in the Fig.

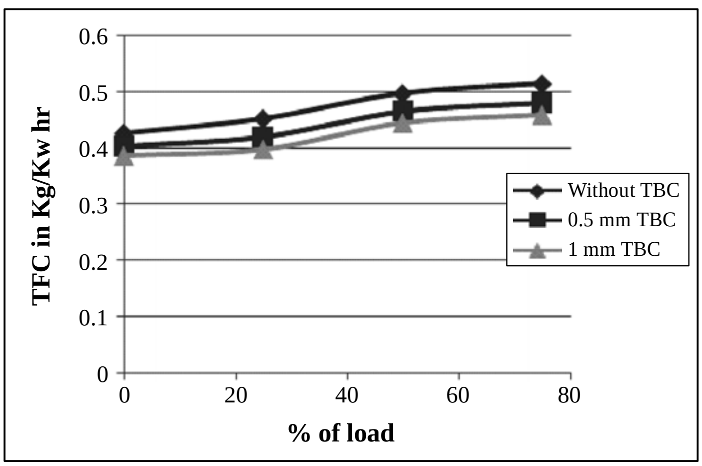

Fig. 3: % of load Vs TFC

Specific fuel consumption

Specific fuel consumption is the ratio of the total fuel consumption to the brake power. The specific fuel consumption of the engine is reduced after the thermal barriers coating.

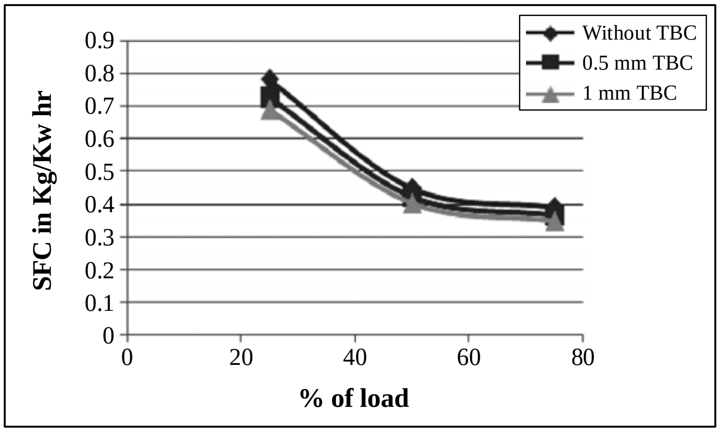

Fig. 4: % of Load Vs SFC

Brake thermal efficiency

The brake thermal efficiency is finding by the formula. The brake thermal efficiency is mainly based on the temperature inside the combustion chamber. If the temperature is increased in the combustion chamber the efficiency is increased, if the operating temperature is decreased the efficiency is also decreased.

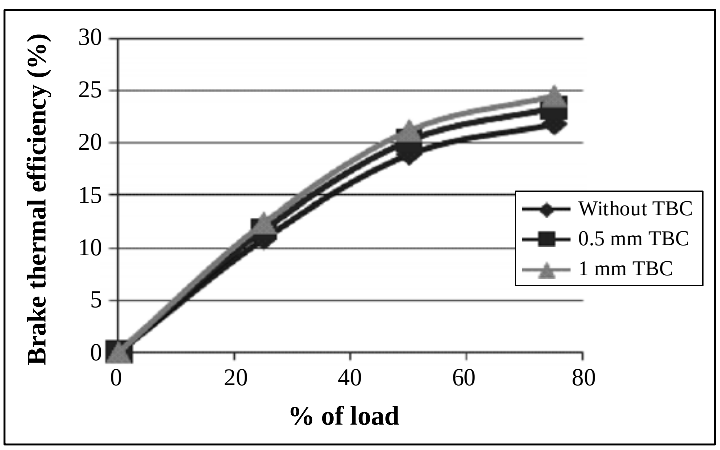

Fig. 5: % of Load Vs brake thermal efficiency

Hydrocarbon

Concentration of the exhaust in parts per million (ppm). = Unburned petrol represents the amount of unburned fuel due to incomplete combustion exiting through the exhaust. This is a necessary evil. We don't want it so try to keep it as low as possible. An approximate relationship between the percentage of wasted fuel through incomplete combustion and the ppm of HC is about 1/200 (1.0% partially burned fuel produces 200 ppm HC, 10% = 2000 ppm HC, 0.1% = 20 ppm HC).

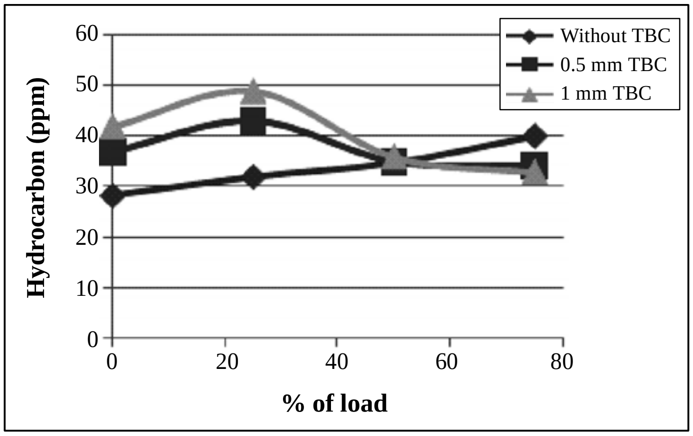

Fig. 6: % of load Vs hydrocarbon

Oxides of nitrogen

This is only seen by a 5-gas analyser; only seen with dynamometer or engine under load. NOx emissions rise and fall in a reverse pattern to HC emissions. As the mixture becomes leaner more of the HC's are burnt, but at high temperatures and pressures (under load) in the combustion chamber there will be excess O_2 molecules which combine with the nitrogen to create NOx. NOx increases in proportion to the ignition timing advance, irrespective of variations in A/F ratio.

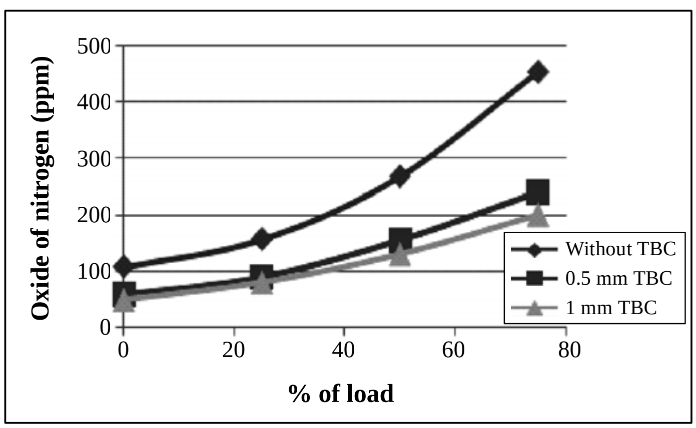

Fig. 7: % of Load Vs oxides of nitrogen

This gas is related to the exhaust gas detoxification systems (in conjunction with Co and HC), exhaust gas recirculation systems. Those systems bring some of the inert (processed) exhaust gas back in to the engine to be burned again. This time around this gas has no O_2 extra molecules and prevents high combustion temperatures and further increase in NOx formation. NOx is very dangerous lethal gas and air pollutant.

Carbon monoxide

Concentration of the exhaust in percent of the total sample. = Partially Burned Petrol, This is the petrol that has combusted, but not completely. This gas is formed in the cylinders when there is incomplete combustion and an excess of fuel. Therefore, excessive CO contents are always a sign of an overly rich mixture preparation. (The CO should have become CO_2 but did not have the time or enough O_2 to became real CO_2 so it is exhausted as CO instead.) CO is Highly Poisonous Odorless Gas. It always works in well ventilated areas.

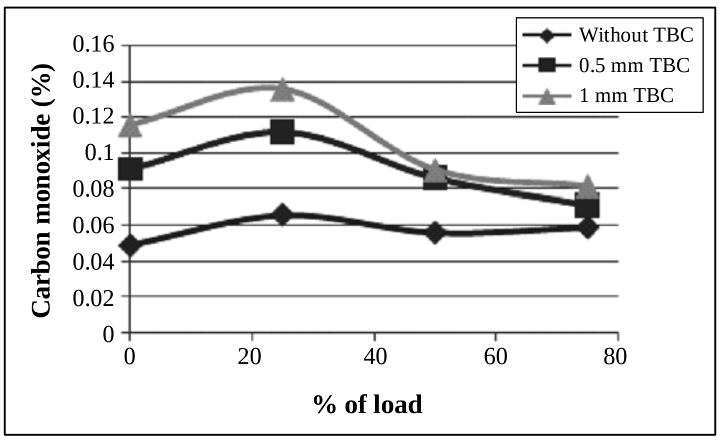

Fig. 8: % of Load Vs carbon monoxide

CONCLUSION

In this paper, the advantages and disadvantages of several materials for use as thermal barrier coatings in diesel engines were reviewed. A multi-layer system is a promising approach to satisfy the competing requirements of the coating. The thicknesses of the different layers must be optimized to minimize the stresses under service conditions.

The result is compared with the condition of the engine performance and emissions are1 mm TBC compared with different level TBC in the same engine. The positive results are came like decreases of SFC and TFC. Increases in the brake thermal efficiency and the emissions are reduced after coating the engine. This will give the better performance of the engine compared to the steady state condition of the single cylinder, four stroke, water cooled, direct ignition diesel engine. The graphs show the better understanding of the performance results of the engine with different thickness of TBC.

REFERENCES

1. R. L Jones, Thermal Barrier Coatings, in Metallurgical and Ceramic Coatings, Chapman & Hall, London (1996).
2. U. Schultz et al., Some Recent Trends in Research and Technology of Advanced Thermal Barrier Coatings, Aerospace Sci. Technol., **7**, 73-80 (2003).
3. S. Jaichandar and P. Tamilporai, Low Heat Rejection Engines – An Overview, SAE World Congress Detroit, Michigan, March 3-6 (2003).
4. M. Cerit, V. Ayhan, A. Parlak and H. Yasar, Thermal Analysis of a Partially Ceramic Coated Piston: Effect on Cold Start HC Emission in a Spark Ignition Engine, Appl. Thermal Engg., **31**, 336-341 (2011).
5. B. Rajendra Prasath, P. Tamilporai and Mohd. F. Shabir, Analysis of Combustion, Performance and Emission Characteristics of Low Heat Rejection Engine using Biodiesel, Int. J. Thermal Sci., **49**, 2483-2490 (2010).
6. M. F. Shabir, P. Tamilporai and B. Rajendra Prasath, Analysis of Combustion, Performance and Emission Characteristics of Turbocharged LHR Extended Expansion DI Diesel Engine, World Academy of Sci. Engg. Technol., **61** (2010).
7. L. Kamo and M. Woods, Thermal Barrier Coatings for Monolithic Ceramic Low Heat Rejection Diesel Engine Components, SAE 2000 World Congress Detroit, Michigan, March, 6-9 (2000).
8. A. Tricoire, B. Kjellman, J. Wigren, M. Vanvolsem and L. Aixala, Insulated Piston Heads for Diesel Engines, J. Thermal Spray Technol., **18(2)**, 217.
9. S. H. Chan and K. A. Khor, The Effect of Thermal Barrier Coated Piston Crown on Engine Characteristics, J. Mater. Engg. Performance, **9(1)** (2000).
10. A. D. Jadhav, N. P, Padture, E. H. Jordan, M. Gell, P. Miranzo and E. R. Fuller Jr, Low Thermal-Conductivity Plasma-Sprayed Thermal Barrier Coatings, Engineered Microstructures, **54**, 3343-3349 (2006).
11. A. P. Sathiyagnanam, C. G. Saravanan and S. Dhandapani, Effect of Thermal-Barrier Coating Plus Fuel Additive for Reducing Emission from Di Diesel Engine, Proceedings of the World Congress on Engg., London, UK, **2**, WCE 2010, June 30 - July 2 (2010).

12. T. Hejwowski, Comparative Study of Thermal Barrier Coatings for Internal Combustion Engine, Vacuum, **85**, 610-616 (2010).

13. A. L. Boehman, M. Vittal, J. A. Borek, D. A. Marks and A. P. Bentz, The Effects of Thermal Barrier Coatings on Diesel Engine Emissions, ASME ICE, **29-3**, 25-32 (1997).

14. S. Chan S., H. and Khor K., A., The Effect of Thermal Barrier Coated Piston Crown on Engine Characteristics, J. Mater. Engg. Performance, **9(1)**, 103-109 (2000).

15. L. Wang, X. H. Zhong, Y. X. Zhao, S. Y. Tao, W. Zhang, Y. Wang and X. G. Sun, Design and Optimization of Coating Structure for the Thermal Barrier Coatings Fabricated by Atmospheric Plasma Spraying Via Finite Element Method, J. Asian Ceramic Soc., **2**, 102-116 (2014).

16. D. Freiburg, D. Biermann, A. Peukera, P. Kersting, H. J. Maier, K. Möhwald, P. Knödler, M. Otten, Development and Analysis of Microstructures for the Transplantation of Thermally Sprayed Coatings Procedia CIRP, **14**, 245-250 (2014).

17. T. Hejwowski and A. Weronski, The Effect of Thermal Barrier Coatings on Diesel Engine Performance, Vacuum, **65**, 427-432 (2002).

Revised : 12.01.2016 *Accepted : 15.01.2016*