iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** VIII **Month of publication:** August 2019

DOI: http://doi.org/10.22214/ijraset.2019.8151

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VIII, Aug 2019- Available at www.ijraset.com

Investigate the Effect of different Thermal Barrier Piston Coating Materials on the Performance and Emission Characteristics of CI engine

Pashupati Nath Mishra[1], Vipin Mehta[2]
[1, 2]*Mechanical Engineering, RGPV, Bhopal*

Abstract: In the present work experiments are conducted on D.I. Diesel engine with tangential grooved piston and waste vegetable methyl esters biodiesel blended with diesel in B20D80 proportions. The effect of tangential grooves on piston crown on the performance and emission characteristics is studied. Brake specific energy consumption decreases and thermal efficiency of engine slightly increases when operating on blended fuel of 20% waste vegetable methyl esters biodiesel (WVOME) and 80% diesel (20BD) than that operating on diesel fuel. From the experimental investigations, it is found that 200 bar is the optimum injection pressure with 20BD blend of WVOME, which has resulted in better performance and emission characteristics among the biodiesel blends. Based on the results it is concluded that the base line engine with tangential grooved piston configuration (TGP-2) gives maximum performance in all aspects and reduces emissions.

***Keywords*: D.I. Diesel engine, waste vegetable methyl esters biodiesel, Tangential Grooved Pistons, Blended fuel, BSFC, CO, NOx, HC Emissions.**

I. INTRODUCTION

Internal combustion engines are self propelled engine in which combustion of fuel takes place inside engine cylinder, high pressure combustion product would be expanded through the piston thus work produced. An Internal combustion engine parts are exposed to severe gas loads, high temperature, as well as corrosion and erosion media. Engine life depends mainly on the part of the engine service life increased by considering the part which dominates its major role in the working condition of the engine. The engine manufacturer as well as automobile industry is facing a serious challenge to improve engine efficiency and reduce emission. Reductions in fuel consumption can be achieved by a variety of measures, including improved aerodynamics, weight reductions and hybrid power trains. Since the early stages of modern engine construction, their producers have been applying protective coating systems in order to enhance their durability and to maximize the exploitation of the properties of the used materials Modern engine constructions together with the technological advancement lead to the evolution of new coating types and to the improvement of the formerly used coatings. The present's applications of a variety of protective coatings for the piston crown of an I.C. Engine. However, in the hot section of the engine, which includes piston, the combustion chamber area the thermal barrier coatings (TBCs) and high-temperature seal coatings are used. The hot operating temperature of the parts demands the application of Advance ceramic material. The developmental tendencies in obtaining high performance of I.C. engine are chiefly connected with an increase in the engine's capacity, its efficiency, lifetime, reliability; reduce emission and a decrease in the fuel consumption. These may be achieved with the development of ceramic coating for thermal insulation system for minimal heat rejection of heat and metal protection of hot gases faced in cylinder component is continued with emphasis on plasma spray

Those materials need to be resistant to the high temperature of the gas stream, which may have a strong oxidizing, corroding or eroding impact. The influence of the destructive environment might be incredibly complex, depending on the engine construction, its working cycle, the used fuel and its operation site.

A. Methods to Produce Thermal Barrier Coatings

1) Thermal Barrier Coatings Can Be Produced In Industries By The Following Methods

a) Air Plasma Spray (APS)
b) Electron Beam Physical Vapour Deposition (EBPVD)
c) High Velocity Oxygen Fuel (HVOF)
d) Electrostatic Spray Assisted Vapour Deposition (ESAVD) and
e) Direct Vapour Deposition (DVD)

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VIII, Aug 2019- Available at www.ijraset.com

2) *Advanced Technology Ceramics Consist Of Pure Oxides And Type Of Ceramic Material*
a) Alumina (Al2O3),
b) Zirconia (ZrO2),
c) Magnesia (MgO),
d) Barilla (BeO),
e) Yttria (Y2O3) and non oxide ones.
f) Garnets
g) Spinel
h) Mullite

3) *Benefits of Ceramic Coated Piston*

When performance of C.I. engine takes place with ceramic coated piston by experiment and fin ite element analysis, it offers the following advantages:
a) Reduction in friction
b) Low cetane fuels can be burnt.
c) Improvements occur at emissions.
d) Waste exhaust gases are used to produce useful shaft work,
e) Increased effective efficiency,

II. EXPERIMENTAL SETUP

The experimental setup consists of the following equipment

A. Single cylinder DI-diesel engine loaded with rope dynamometer
B. Engine Data Logger
C. Exhaust gas Analyzer
D. Smoke Analyzer

1) *Direct injection (DI) Diesel Engine*

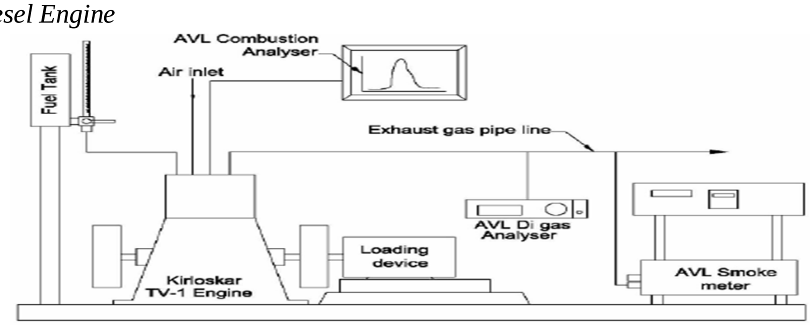


Fig. 2.1 Test Engine

2) *Single cylinder 4 Stroke Diesel (CI) Engine Experimental Set-up:* Single Cylinder 4 stroke (CI) Engine test kit was installed in the research Laboratory of FRICK India limited. Details along with technical specifications of this kit being discussed as below.

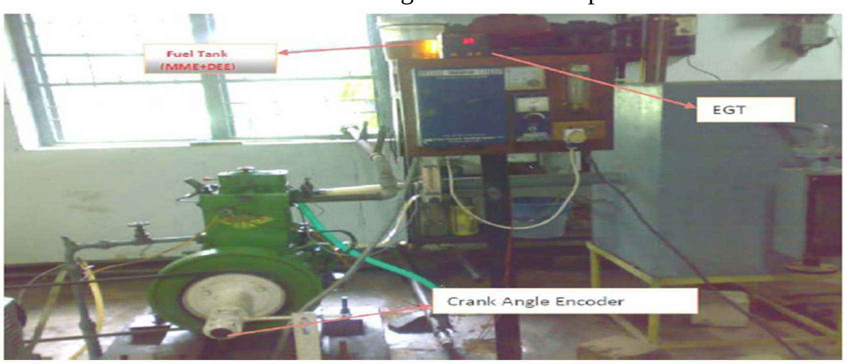


Fig. 2.3 experimental setup

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VIII, Aug 2019- Available at www.ijraset.com

TABLE I
Specifications of the Test Engine

MAKE	Kirloskar Oil Engine,
MODEL	SV1
TYPE	Four Stroke Cycle, Water cooled engine.
NO. Of CYLINDER:	ONE
BORE	87.5 mm
STROKE	110 mm
CUBIC CAPACITY	662 CC
COMPRESSION RATIO	16.5: 1
RPM	1500
RATE OF OUTPUT	8 HP
MODE OF INJECTION AND INJECTION	Direct Injection, 200 kg/cm^2

3) *Experimental Procedure:* The experimentation is conducted on the single cylinder direct injection diesel engine operated at normal room temperatures of 28 0C to 33 0C in the Frick India limited. The fuels used are Diesel fuel in neat condition and as well as methyl ester of waste vegetable oil (WVOME) with 20% blends and at Full Loads condition. The data collection is done independently for the above said oils. The engine is initially made to run at 1500 rpm continuously for one hour in order to achieve the thermal equilibrium under operating conditions.

a) *Fuel Consumption Measurement:* Time taken for 10 ml consumption of fuel is recorded at full load with WVOME. Same procedure is repeated with diesel operation at the same full load conditions with different coating pistons for comparison. Finally the fuel consumption is expressed in kg/hr.

b) *Combustion Pressure Measurement:* The Piezo electric transducer is fixed (flush in type) to the cylinder body (with water cooling adaptor) to record the pressure variations in the combustion chamber for each and every degree of crank angle. Crank angle is measured using crank angle encoder. Exact TDC position is identified by the valve timing diagram and fixed with a sleek mark on the fly wheel and the same is used as a reference point for the encoder with respect to which the signals of crank angle will be transmitted to the data Logger. The data logger synthesizes the two signals and finally the data is presented in the form of a graph on the computer using C7112 software.

c) *Emission Measurement:* AVL Exhaust Gas Analyzer collects the exhaust gas from the exhaust piping, measures and provides the values mainly about six components of it namely nitric oxide, hydro carbons, carbon monoxide, carbon dioxide, oxygen and free air either in the percentage basis or as parts per million in the printed format.

d) *Smoke Measurement:* Exhaust suction gun collects gas sample by suction. During this process the smoke paper placed inside the suction gun absorbs the smoke. The smoke density is measured using the Diesel Tune Smoke Analyzer and then converted in HSU units by using proper conversion tables.

e) *Exhaust Gas Temperature Measurement:* Exhaust gas temperatures for each and every load with diesel as well as MME implementation for all the exhaust gases are recorded by means of a temperature measuring (thermocouple based) device (Figure 4.13) whose sensor is placed on the exhaust pipe immediately after the exhaust valve.

Fig. 2.4 AVL smoke and emission analyzer

Fig. 2.5 AVL computer software

Before going to start the engine check whether there is any air gap in between the cylinder head and piston. The experimentation is conducted on the single cylinder direct injection diesel engine operated at normal room temperatures of 280C to 330C in the FRICK India limited. The fuels used are Diesel fuel in neat condition and as well as methyl ester of waste vegetable oil (WVOME) with 20% blends and at Full Loads condition. The data collection is done independently for the above said oils. The engine is initially made to run at 1500 rpm continuously for one hour in order to achieve the thermal equilibrium under operating conditions.

TABLE II
Plasma spray coating specifications

Coating parameters	Specifications
Plasma gun	3 MB plasma spray gun
Nozzle	GH Type nozzle
Pressure of organ gas	100–120 PSI
Flow rate of organ gas	80–90 LPM
Pressure of hydrogen gas	50 PSI
Flow rate of hydrogen gas	15–18 LPM
Powder feed rate	40–45 g per minute
Spraying distance	3–4 in.

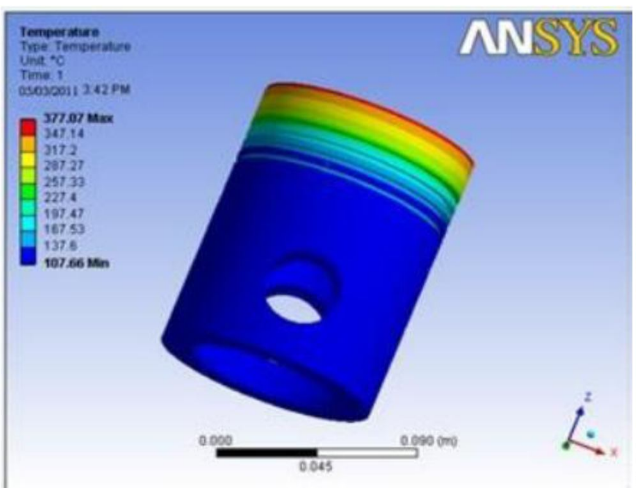


Fig 2.6 Ceramic material Zirconia coated piston

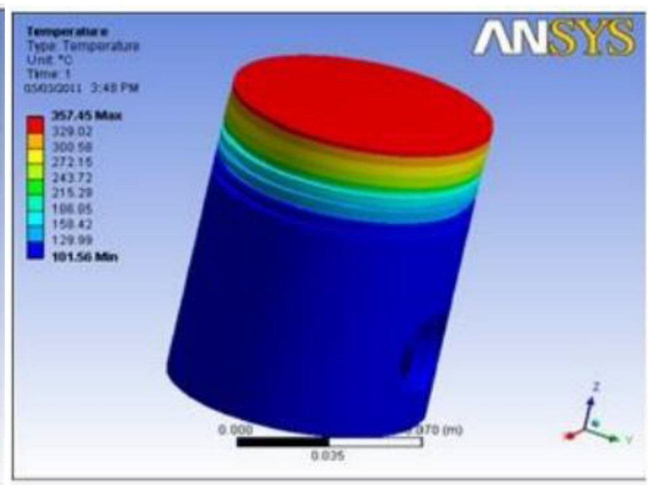


Fig 2.7 Ceramic material Alumina coated piston

III. RESULTS

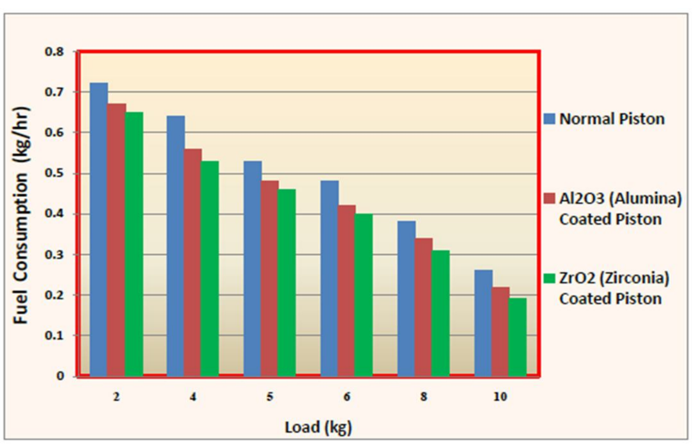


Figure 3.1 Variation of fuel consumption with load

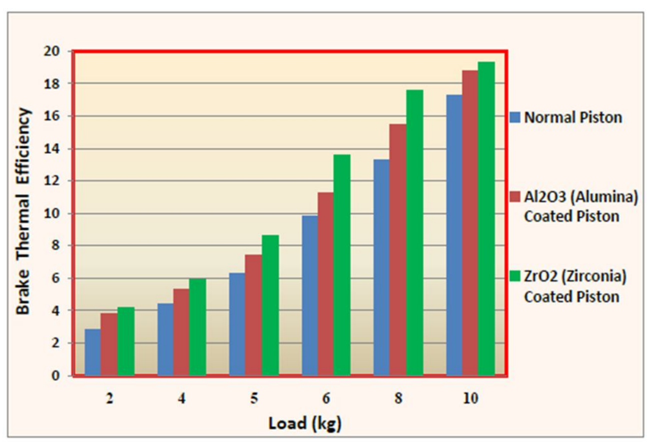


Figure 3.2 Variation of brake thermal efficiency with load

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VIII, Aug 2019- Available at www.ijraset.com

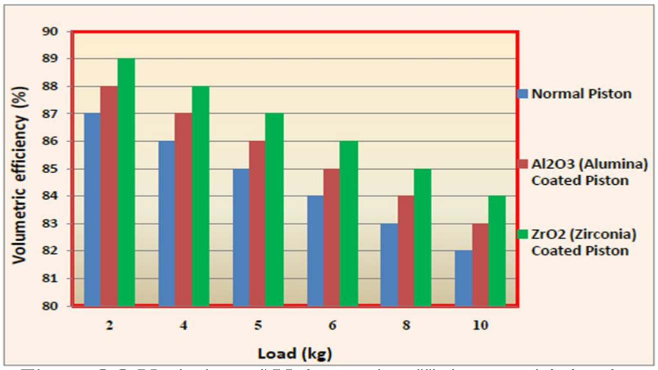


Figure 3.3 Variation of Volumetric efficiency with load

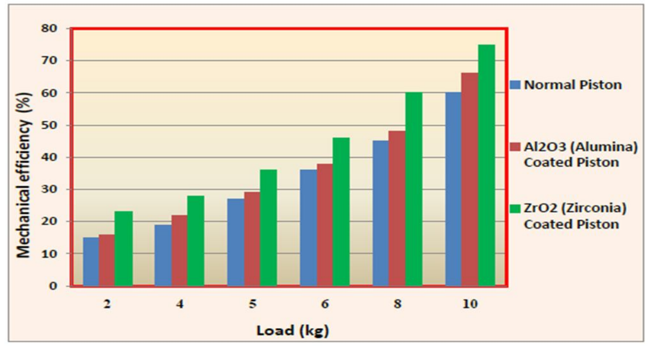


Figure 3.4 Variation of mechanical efficiency with load

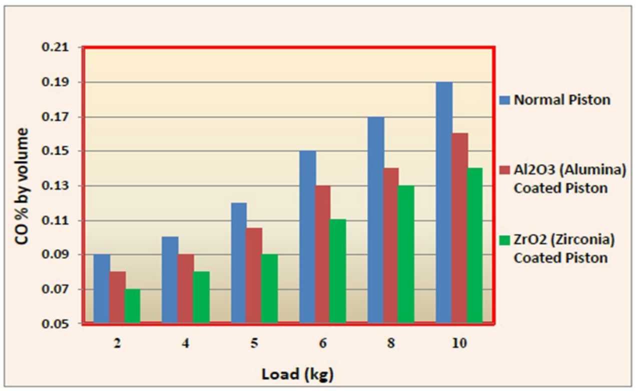


Figure 3.5 Variation of carbon monoxide emission with load

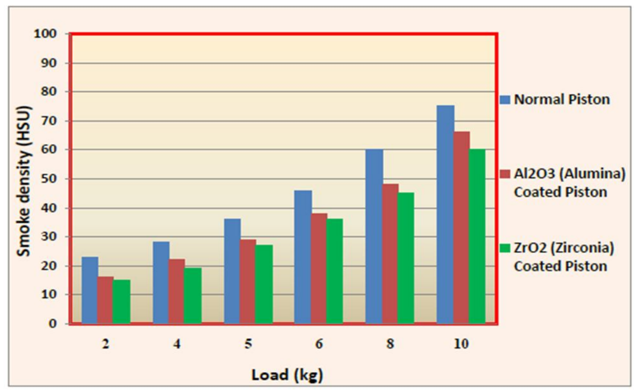


Figure 3.6 Variation of smoke density with load

IV. CONCLUSIONS

A. Fuel consumption is very less for coated piston about 8% less, here ZrO_2 (Zirconia) gives lower fuel consumption than Al_2O_3 (Alumina) coated piston.

B. Brake thermal efficiency high for coated piston, here ZrO_2 (Zirconia) gives higher brake thermal efficiency than Al_2O_3 (Alumina) coated piston.

C. Volumetric efficiency: highest in case of 0.25mm diameter nozzle size and lowest for 0.5 mm nozzle size at different loads.

D. Mechanical efficiency: highest in case of 0.25mm diameter nozzle size and lowest for 0.5 mm nozzle size at different loads.

E. Carbon monoxide emission very less for coated piston. here ZrO_2 (Zirconia) gives lower Carbon monoxide than Al_2O_3 (Alumina) coated piston. .

F. Smoke density very less for coated piston, here ZrO_2 (Zirconia) gives lower Smoke density than Al_2O_3 (Alumina) coated piston.

REFERENCES

[1] Ashish Jashvantlal Modi and Dhiren Patel ,Experimental Study on Diesel Engine Performance with Blends of Diesel and Neem biodiesel, SAE International , 2015-26-0052, 2015

[2] Y. Sureshbabu, P. Ashoka Varthanan Presents on ―Study the emission characteristics of catalytic coated piston and combustion chamber of a four stroke spark ignition (SI) engine, JCHPS, 0974-2115, 2014

[3] Parag C.Thanare, R. G. Telrandhe Presents on‖ Design And Analysis Of Piston Head With Different Coat‖ IJSRES ,2349-8862 ,2015

[4] Vinay Kumar Domakonda , Ravi Kumar Puli, Application of thermal Barrier Coatings in diesel Engines, 9-17,2012

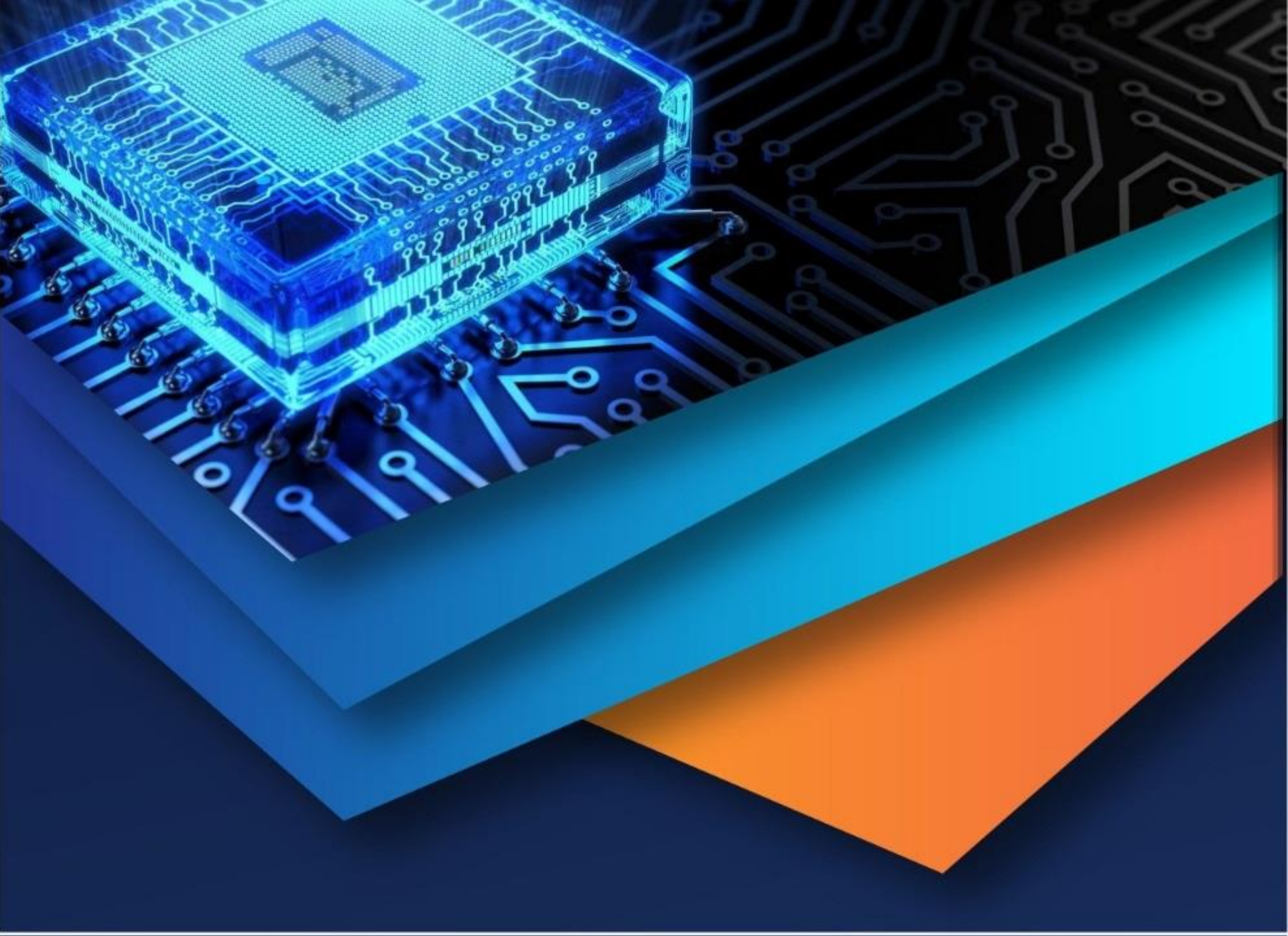
[5] R.R. Saraf, Dr.P.K.Saxena, Dr. S.S. Thipse, Lambda Characterization of Diesel-CNG Dual Fuel Engine, IEEE 978-0-7695-3937-9/09, 2009

[6] Helmisyah Ahmad Jalaludin, Shahrir Abdullah, Mariyam Jameelah Ghazali, Bulan Abdullah, Nik Rosli Abdullah presents ―Experimental study of ceramic coated piston crown for compressed natural gas direct injection engines‖ AIJSTPME ,73-77,2012

[7] G. Sivakumar, S. Senthil Kumar ,Investigation on effect of Yttria Stabilized Zirconia coated piston crown on performance and emission characteristics of a diesel engine- Alexandria Engineering Journal, 787–794, 2014

[8] Sean D'silva , Sumit Jain, Mayur Ingale ,Design Analysis of a Circular and Square Shaped Piston Head Considering Mechanical Stresses, IJMERA, 2347-1719 ,2013

[9] M Azadi ,M. Baloo ,A review of thermal barrier coating effects on diesel engine performance and components lifetime‖ 201-206, 2013



doi crossref

10.22214/IJRASET

INDEX COPERNICUS

45.98

ISRA JIF

IMPACT FACTOR: 7.129

SJIFactor

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

ISI

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY