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Thermal barrier coating effects on diesel engine perfomance & emmision: A review

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Abstract
In present manuscript, A entire literatures review of thermal barrier coating applications in diesel engines is performed to select suifigtype & to locate coating effects. The coating system has special effects on the fuel consumption, the power and the combustion efficiency, pollution contents. Usually there are several beneficial influences by applying ceramic layers on the combustion chamber as well as the piston, the cylinder head, the cylinder block, and intake and exhaust valves by using a plasma spray method. Also several disadvantages such as producing nitrogen oxides also exist when a coating system is used. In this editorial, all effects, advantages and disadvantages of thermal barrier coatings are investigated based on existing articles.

Keywords: performance, emission, manuscript, applications

Introduction

At the present time many research programs, in automatic industries or several other sectors,are moving out in order to decrease engine fuel consumption & other hand for pollution. To run the world energy must be needed ; so Energy is the quantitative property that must be transferred to an thing in order toward perform work on, or to heat, the thing. Energy can be converted from one form to another in a range of other ways. By use through mechanical or electrical energy is for illustration produced by many kinds of devices: including fuel-burning heat engines, generators, batteries, fuel, and magneto hydrodynamic systems. Our energy contribute comes mainly from fossil fuels, Diesel, petrol, with nuclear power and renewable sources.But mainly we use spark ignition, compression ignition engines for day today life mostly. Diesel engines mainly used in trucks, bus, trains, boats, and barges help transport almost all products people use, also Diesel fuel powers most of the farm and construction equipment & industries to run. first know that Diesel engine identified as a compression-ignition or CI engine) is an internal combustion engine in which ignition of the fuel, which is injected into the burning chamber, is caused by the prominent temperature of the air in the cylinder due to the mechanical compression (adiabatic compression). Diesel engines work by compressing only the air. This increases the air temperature inside the cylinder to such a high degree that atomized Diesel fuel injected into the burning chamber ignites spontaneously. Rudolf Christian Karl Diesel, German thermal engineer who made-up the internal-combustion engine that bears his name.So design of diesel engines with lower heat rejection, by applying tbc is growing according to fast raise in fuel costs, decrease in fuel production with high value and environmental problems. Normally, in diesel engines about 19-22 percent of fuel force is unwanted to coolant fluid. Using TBC can reduce this heat loss and lead to better thermal efficiency. Also engine components stability can be improved. Therefore, better combustion, lower pollution, higher thermal efficiency and good fatigue lifetime are the outcomes of using proper TBC in engine combustion chamber and exhaust system.A major breakthrough in diesel engine technology has been achieved by the pioneering work done by Kamo and Bryzik since 1978 to 1989 as the first persons in introducing TBC system for engines. They mainly used silicon nitride for insulating different surfaces of ignition chamber. Many researchers have carried out a large number of studies on design of diesel engines with lower heat rejection (LHR using thermal barrier coating (TBC), considering both theoretical & experimental work. LHR engine almost all hypothetical studies found improved performance and fuel financial system but some experimental studies show different image. The efficiency of most commercially available diesel engine ranges from 38% to 42%. Diesel engine generally offers better fuel economy than its counterpart petrol engine. Other hand a diesel engine; the exhaust gas emissions like carbon monoxide emissions (CO), nitrogen oxides (NO_x) and carbon dioxide (CO_2) which is injurious or dangerous to climate, Even the diesel engine discards about two thirds of the heat energy of the fuel, one-third to the coolant, and one third to the exhaust, parting only about one-third the similar as useful power output. Theoretically, if the heat rejected could be reduced, then the thermal efficiency would be enhanced, at least up to the boundary set by the second law of thermodynamics. LHR engines intend to do this by dropping the heat lost to the coolant.

Here literatures review of TBC application in engines is performed to examine all effects of TBC systems on engine performance. As a outcome, by considering the application of this type of ceramic coating which is made on combustion chamber, dependent on the diesel engine category,fuel consumption is reduced, power and combustion efficiency is improved, pollution contents is decreased.

General Review

Mainly diesel engine with its combustion compartment walls insulated by ceramics is referred to as LHR

engine. Many researchers conclued that insulation reduces heat transfer, improves thermal efficiency, and increases energy accessibility in the exhaust. For the above prospect some experimental studies have indicated almost no improvement in thermal efficiency and claim that exhaust emissions deteriorated as compared to those of the conservative water-cooled engines. several simulation studies have been carried out to get the performance of the insulated engine. simulation works calculate definite enhancement in the thermal performance of LHR engines over the conservatively cooled engines. In some cases simulations are carried on single cylinder, light duty and direct injection diesel engines. variation is mainly due to different amount of reductions in-cylinder heat rejections effected by degrees of insulations and dissimilar quantities of energy improved from the exhaust. The use of reduced heat rejection in diesel engines is least useful in naturally aspirated engines, more useful in turbocharged engines. In order to obtain enhanced performance over a wide range of engine loads it becomes required to match the engine with a turbocharger. As all-purpose, Winkler *et al*. [1, 2] reported ten years of experience for the role of ceramic coatings on a diesel engine (Cummins) in dropping automotive emissions and improving combustion efficiency (Fig1). In the next parts of this study, belongings of the TBC system on the fuel utilization, emissions (including nitrogen oxides, smoke, un-burned hydrocarbon and carbon monoxide), the engine administration (including volumetric and thermal efficiency), the temperature allotment, the stress field and the fatigue lifetime were obtainable.

Fig1: Ten years experience for Tbc Applications [1-2]

possessions	variation Type	maximum variation amount
Fuel expenditure	Decrease	11
Engine duration	Increase	20
Engine power	Increase	10
Emission	Decrease	20-50
Particle	Decrease	52
Oil utilization	Decrease	15
Engine noise	Decrease	3 (db)
(Reliability)	Increase	-
Components		
Temperature (°C)	Decrease	100
Valves lifetime	Increase	300
Costs	Decrease	20

Fuel Consumption

Bahattin IS Can. [3] Investigated submission of ceramic coating for improving the usage of cottonseed oil in a diesel engine. Here they used of a pure vegefigoil of cottonseed in diesel engines was anticipated. With this principle, piston surface and valves of the test engine were coated with zirconium oxide (ZrO2) ceramic coating material in order to decrease the heat rejected from the mentioned parts.Then waste cottonseed oil was volumetrically blended with petroleum based diesel fuel by 15% cottonseed oil e 85% petroleum diesel (CO15), 35% cottonseed oil e 65% petroleum diesel (CO35) and 65% cottonseed oil 35% petroleum diesel (CO65), the petroleum based diesel fuel with number: 2 (D2) fuel was tested in the usual uncoated only cylinder diesel engine. These blend fuels and D2 were then tested in the coated engine. Outcomes were compared with the outcomes of initial test of D2 in uncoated engine procedure. The comparison of all the test outcome showed that the coating process considerably improved the performance of the test engine for all the test fuels. Besides, every measured pollutant emissions were reduced only except for oxides of nitrogen (NOx). As a outcome coating process was a sensible method for using pure vegefigoils in diesel engines provided that the injection process runs well for so long.

Sharukh K *et al*. [4]. Experimented Analysis of YSZ Coating on an Internal Combustion Engine Piston. Here an endeavor was taken to reduce the concentration of heat rejection by using a layer of the ceramic material, like Yttrium Stabilized Zirconia (YSZ) which has low thermal conductivity, high thermal resistance, chemical inertness, high resistance to erosion, corrosion and high strength was selected as a coating material for engine component. In this paper the experiments were carried out with 0.4mm YSZ coated piston and it is found that it has 1% total fuel expenditure 1.2% specific fuel consumption and 0.7% exhaust gas temperature fewer than the conventional engine with uncoated piston. It is also seen that 2.6% brake thermal competence, 2.14% indicated thermal efficiency and 1.35% mechanical efficiency more than the predicfigengine with uncoated piston.

V. Karthickeyan [5]. Studied consequence of cetane enhancer on Moringa oleifera biodiesel in a thermal encrusted through injection diesel engine. Here Raw Moringa oleifera oil was rehabilitated into biodiesel using transesterification technique. The physical and chemical properties were examined based on ASTM standards and compared with diesel. The chemical composition of biodiesel was examined with Fourier Transform Infrared Spectroscopy and Gas Chromatography and Mass Spectrometry (GC–MS). To get enhanced the properties of the prepared biodiesel sample, an anti-oxidant namely 1% Pyrogallol was added. The engine combustion chamber components similar to piston head, cylinder head and intake and exhaust valves were thermally coated with Yttria Stabilized Zirconia (YSZ) to switch over the conventional engine into low heat negative response engine. Kirloskar TV1 model direct injection water cooled diesel engine with eddy current dynamometer was used for experimental analysis. In coated engine, the improved brake thermal efficiency and reduced brake specific fuel expenditure were observed with biodiesel and additive blend. As outcome they establish that In uncoated engine, diesel showed higher BTE than biodiesel with anti-oxidant blend due to higher calorific value. In coated engine, Higher BTE was investigational with MOME+PY than diesel. In uncoated engine, diesel showed lower BSFC than MOME+PY due to better fuel properties. Biodiesel with anti-oxidant blend showed lower BSFC than diesel in coated engine.

Debajit Mohapatra *et al*. [6] Investigated outcome of steam injection and FeCl3 as fuel additive on presentation of thermal barrier coated diesel engine.They investigated, combustion and emission characteristics of yttria stabilised zirconia (YSZ) coated diesel engine below the combined end product of steam injection and ferric chloride (FeCl3) as fuel chemical addition were studied. The outcomes indicated that, addition of 0.2 g L_1 FeCl3 with diesel in YSZ coate d engine along with steam injection condensed the emissions such as carbon monoxide, hydrocarbons, nitrogen oxide and smoke opacity by 33, 42, 31 and 59, correspondingly, as compared to standard diesel mode in uncoated engine. As a outcome they found that the brake thermal efficiency improved by 2.5% and brake specific fuel expenditure reduced by 5.5% demonstrating the effectiveness of the collective effect of steam injection in the coated engine.

Emmisions

There are two types of Emission's like
*Unburned Hydrocarbon & Monoxide Emissions
*Nitrogen Oxides & Smoke

M Ciniviz *et al.* [7] Studied contact of thermal barrier coating application on the performance and emissions of a turbocharged diesel engine. The effect of thermal-barrier-coated piston top and combustion chamber surfaces on turbocharged diesel engine presentation was experimentally investigated. Performance was obtained with TBC1 (with coated cylinder head & valves) and TBC2 (with coated cylinder head, piston top) & they compared with standard diesel engine. They found that engine power was improved by 2 per cent, the engine torque was superior by 1.5–2.5percent, and brake specific fuel consumption was decreased by 4.5–9 per cent. The NOx emissions were improved by 10 per cent in diesel engines with TBC coatings compared with a standard diesel engine also found that diminution in smoke emissions of up to 18 percent as a outcome of TBC appliance.

P. Sakthivel *et al.* [8] Studied Effect Of TiO2/Al2O3 Catalyst covering On Catalyst Converter With Ethanol Diesel Blend In Single Cylinder Four Stroke VCR Engine. They investigated outcome of ceramics material on a novel catalytic converter to be used for diesel fuelled engine with 10% of ethanol blend in addition of 1% of Diethyl Ether. The catalytic converter was developed based on catalyst materials consisting of metal oxides such as titanium dioxide (TiO2) and Aluminum oxide (Al2O3) with ceramics substrate. In this study experimentally found the outcome that the TiO2/Al2O3 based catalytic converter are trim down 12%, 23.46%, 19%, 35% and 77.9% for NOx, CO, HC, CO2 and smoke emissions effectively reduce. It was calculated that the TiO2/Al2O3 based catalytic converter with ethanol 10% in accumulation of DEE 1% reduces 15%, 52.8%, 39%, 40% and 81.7% higher NOx, CO, HC, CO2 and smoke emissions in evaluation to diesel and ethanol.

D. BALAJI *et al.* [9] Experimented On Engine Emission & Perfomance In Diesel Engine By Aluminum Taitanium Tbc. Coating breadth has been discussed with conventional coating equipment, aluminium-titanium and their consequence in the performance of the engine is deliberated. Here, they differ the coating thickness of the TBC material in the combustion chamber and evaluate the performance of the IC engine. The thicknesses of the different layers must be optimized to decrease the stresses under service conditions. The outcome was compared with the condition of the engine performance and emissions are 1 mm TBC compared with diverse level TBC in the similar engine. The positive outcome found that decreases of SFC and TFC. Raises in the brake thermal efficiency and the emissions are reduced after coating the engine.

K. Veeraswamy *et al.* [10]. Investigated Emission distinctiveness Of Tbc With Cerium Oxide Nano Additive On Diesel Engine. They studied performance and emission characteristics, combustion of thermal barrier coated DI diesel engine plus point fuel additives. Plasma spray coating (PSC) technique has been used to cover the outside of the piston crown with AlTi about 250 microns. The investigation was conceded out in a single cylinder, four stroke, water cooled DI diesel engine. engine machinery were coated with AlTi by using PSC technique and thickness of 250 microns each. Second part of the examination was carried out by blending of fuel additive cerium oxide (CeO2) with neat diesel fuel in thermal barrier coated diesel engine. The additives are in the load 100mg and added to neat diesel fuel. The experiments were carried out for various loads via 25%, 50%, 75% and highest loads, then the outcomes were compared. The emission from the engine of coated piston and assorted additive fuel recorded is low in case of carbon monoxide of 50%, carbon dioxide by 5%, exhaust gas temperature by 8% and oxides of nitrogen as compare to diesel at 50% and 75% load. But hydrocarbon is high at piston coating and low through fuel additives.

Shakti P. Jena *et al.* [11] Investigation of the consequence of FeCl3 on combustion and emission on diesel engine with thermal barrier coating. Here they Experimanted on the engine performance and emission uniqueness of a single cylinder diesel engine with yttria stabilized zirconia (YSZ) coating on piston crown and valves were studied. The 0.2 g L_1 of ferric chloride (FeCl3) as catalyst was additional into the diesel fuel in both coated and uncoated engines. As a outcome indicates that FeCl3 with diesel in a YSZ coated engine enhanced the brake thermal efficiency by 2.7%, and reduced brake specific fuel consumption by 8.3% as compared to standard diesel form in uncoated engine. The nominated thermal barrier coating improved the ignition in after burning stage foremost to effective use of intake air. Emissions such as carbon monoxide, hydrocarbons and smoke cloudiness were reduced with an boost in emissions of nitrogen oxide and carbon dioxide.

M. Mohamed Musthafa. [12] Investigated progress of performance and emission character on coated diesel engine fuelled by biodiesel with Cetane number enhancing stabilizer. Here they described the expansion of performance and emission characteristics on partly stabilized zirconia (PSZ) coated diesel engine fuelled by biodiesel with cetane number enhancing additive of Di-tertiary-butyl peroxide (DTBP). Additive was added to biodiesel in 1% by volume. The biodiesel was equipped from palm oil using simple base catalyst transesterification procedure Biodiesel with additive and petroleum diesel were used as the test fuels. The test was conducted on a single cylinder, four stroke, water cooled and direct injection coated engine and to determine the performance and emission characteristics of engine running on the test fuels & as a outcome, The entitlement increase in efficiency at maximum load for biodiesel with additive was found by 5.67% and 11.23% compared to the diesel fuel in coated engine and uncoated engine respectively. The brake fuel consumption also decreased appreciably by 8.1% and 19.6% at highest load compared to diesel fuel in coated and uncoated engine correspondingly. The addition of cetane improver has a significant effect in reduction of HC, CO and NOx emissions. It was start off that HC reduced to 5.8% and 15.6%; CO reduced 20% and 42.8% and NOx was reduced to 8.69% and 3.92% at peak load compared to diesel fuel in coated engine and uncoated engine accordingly.

Engine Efficency

2Types of Efficiency are Their Like *Volumetric Efficiency *Thermal Efficiency

J. Modi *et al.* [13] Experimented on Tbc Diesel Engine Performance with Blends of Diesel with Palm Biodiesel.They Proceed captivating ceramic coated twin cylinder water-cooled diesel engine using blends of diesel and palm biodiesel seeing that the fuel was evaluated for its performance and exhaust emissions. Here engine was insulated by Partially Stabilized Zirconia (PSZ) as ceramic material & biodiesel was prepared in laboratory from non-edible vegefigoil (Palm oil).As a outcome they found that the general performance of the TBC engine is set up to be better than the base engine. The mechanical efficiency of the TBC engine is found to be 10-16% superior than the base engine, and an on the whole increase of 10-15% in brake thermal efficiency. The SFC was 5-10% lower than that of the base engine at high load condition. The smoke emission from the TBC engine was 45.74% inferior Than that in the base engine & using of palm biodiesel outcome in lower emissions of unburned hydrocarbons, carbon monoxide, and particulate matter, with some increase in emissions of oxides of nitrogen.

S. Sunit Kumar Reddy *et al.* [14] Studied on Ceramic Coated Diesel Engine amid Brass piston material. They carry on taking a ceramic coated insulated engine devloped by incorporating an air gap between piston skirt and crown for the reading of alcohols performance and emission distinctiveness.They taken brass piston and brass add with nine and twelve grooves. As a outcome they found that the brake thermal efficiency and exhaust gas temperatures with brass piston are more because the brass material due to its lower thermal conductivity acted as a regenerator. The volumetric efficiency of the ceramic engine was condensed with the higher operating temperatures of the chamber.The performance of the lubricating oil deteriorates which further increases the friction in the chamber. All these lubricating oil problems can triumph over with new solid or liquid lubricants.

R. Danavignesh *et al.* [15] Experimented Performance Testing Of Diesel Engine WithTio2coated Engine Parts. Titanium dioxide (TiO_2) was taken as a coating substance. The valves and piston of a single cylinder four stroke Diesel engine were coated with titanium dioxide and a presentation test was carried out. It was observed that improved in performances in terms of indicated thermal efficiency, brake thermal efficiency and mechanical efficiency were obtained. As a outcome TiO_2 believed to be a low thermal conductive material outcomes in enhanced efficiency when coated over the parts of the engine. The efficiency was said to be raise to 5% for coated than uncoated piston for varied injection pressure. Coating outcomes in decreased fuel using up as 0.3 kg/kW hr thus explains that highest utilization of fuel takes place contained by the combustion chamber of the diesel engine.

D.C. Gosai. [16] Studied a relative study on Low Heat Rejection Engine using two dissimilar TBC Materials. Exploration was carried out under dissimilar load condition on a twin cylinder, water cool, and constant 1500 rpm speed diesel engine. The plasma spray coating technology was used for TBC for diesel engine combustion chamber. The one set of combustion chamber inner walls of diesel engine are thermally insulated by top coat of Metco 204NS yttria stabilize zirconia (YSZ) /($Y_2O_3ZrO_2$) with thickness of 350 mm and 150 mm thick bond coats of AMDRY 962 Nickle chromium aluminum Yttria (NiCrAl) correspondingly. The another set of diesel engine ignition chamber top coat by $MgZrO_3Y$ with 350 mm thickness and 150 mm thickness of bond coat by NiCrAlY.. The specific fuel consumption is reduced by 20.58% and 11.60% at full load condition in $MgZrO_3Y$ coated LHRE and YSZ coated LHRE engine respectively. The brake thermal efficiency improved by 26.13% and 13.23% in $MgZrO_3Y$ coated LHRE and YSZ coated LHRE engine correspondingly. The 10.50% and 5.26% higher peak cylinder pressure produce in $MgZrO_3Y$ coated LHRE and YSZ coated LHRE engine correspondingly. The better ignition characterizes found in $MgZrO_3Y$ coated LHRE engine. CO, smoke density, Hc level reduced and NOx level found higher in LHRE engine. Moderately $MgZrO_3Y$ coated LHRE engine found superior combustion, performance and exhaust emissions.

Sachit T S *et al.* [17] studied Thermal analysis of Cr_2O_3 coated diesel engine piston using FEA.As a conclusion Thermal Analysis outcomes indicates that the coating area on the surface of piston, cause an enhance in the temperature as compared to uncoated. It is concluded that due to increase in temperature that improves the combustion in the combustion chamber. Also due to raise in heat flux in coated piston that maintains the required temperature near the chamber and reduces the thermal fatigue in other regions of piston. Also due to thermal barrier coating that controls the temperature flow for other parts of piston that increases the piston existence.

Durability

I.Taymaz *et al.* [18] Experimented on heat losses in a ceramic coated diesel engine. Their main purpose of this study was to appraise the heat losses at different engine loads and speeds with and without ceramic-coated diesel engine. They investigated using a six cylinder, direct injected, turbocharged, intercooled ceramic coated diesel engine: As a outcome they found that By an relevance of 0.5 mm thickness insulation coating at the crown face of the piston, cylinder head and valves, the diminution in heat loss to the coolant is found to be nearly 5–25%, with insulation to reduce the heat loss to the cooling system of the engine causes the cylinder ramparts to become hotter and increases exhaust gas energy. Ceramic-coated diesel engines offer the potential of simplified but thermal efficiency gains.

R. Kalyanasunder *et al.* [19] Studied Effect of Zirconium Coated Piston on the Performance of the Combustion ignition engine Fuelled with Dies El and Bio- Diesel Blends. They studied result of catalytic coated piston on the performance characteristics of a standard undeviating 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 geared up by mixing bio diesel and diesel on volume basis it was pragmatic that with the coated piston, engine performance was improved significantly. The increase in brake thermal efficiency was pragmatic 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.

V. Gnanamoorthi *et al.* [20] Investigated the effect of thermal barrier coating material in CI engine using upper fraction ethanol diesel blend. They proceed taking semi thermal barrier coating (TBC) on Toro dial piston bowl geometry combustion chamber at a higher compression ratio of 19.5:1 in an internal combustion engine. The tests were performed on a single cylinder, four stroke, direct injection, diesel engine using E50 ethanol diesel blend. The engine's piston crown was coated with different TBC materials in different composition ratios such as Aluminium oxide (Al2O3) + Molybdenum (Mo) + Titanium oxide (TiO2) (40%+30%+30%), over a 150µm thickness of NiCrAlY bond coat. The highest thickness of coating is about 300 µm.The engine with and without coating has been tested with the test fuels and diesel fuel in the same in use conditions, As a outcome the brake thermal efficiency was improved in TBC engine mainly depends upon the thermal conductivity of the material. For Mo+Al2O3+TiO2, The BTE is improved by 4.90% The brake specific fuel consumption was decreased in TBC engine. For Mo+Al2O3+TiO2, the BSFC was decreased by 6.55 Kg/KW.hr. The carbon monoxide was decreased in the TBC engine by 4% of volume · The hydrocarbon emission was decreased in the TBC engine. Tbc in piston crown increases NOx emission by 28ppm accordingly.

G. Sivakumar *et al.* [21] Experimented on effect of Yttria Stabilized Zirconia coated piston crown on performance and emission characteristics of a diesel engine. Experimental investigation was carried out under different loading conditions in a three cylinder diesel engine with its piston crown coated with Yttria Stabilized Zirconia (YSZ) to understand the influence of the thermal barrier coating (TBC) on performance and emission characteristics. As a outcome they found that the TBC coated engine shows better Brake thermal efficiency and better BSFC compared to the baseline engine & Brake thermal efficiency is improved at all loads and speed conditions in the TBC coated engine. The improvement is ranging from 1.14% to a maximum of 8.84% at 50% of full load condition TBC coated engine reduces the specific fuel consumption by 3.38% and 28.59% at full load and 25% of the full load conditions respectively when compared to the baseline.Engine also Hydrocarbon emissions were reduced drastically by 35.27% in the TBC coated engine, whereas Carbon monoxide emission is reduced by 2.7% and Carbon dioxide emission is improved by 5.27%.

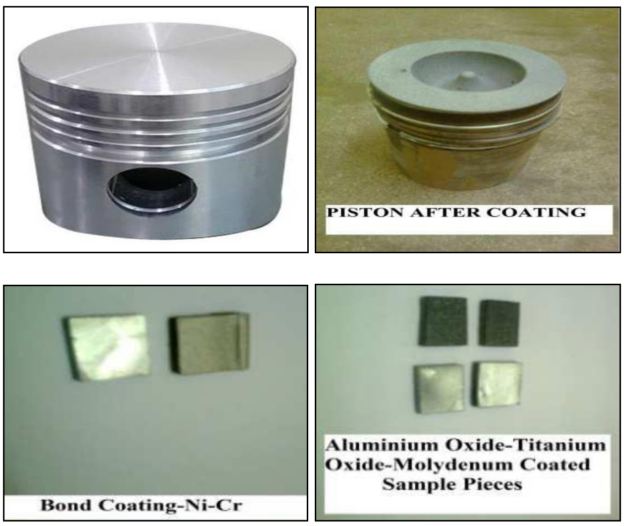

Fig 1: Pistion crown for coated and uncoated specimens

Mingfa Yao *et al.* [22] Studied a theoretical study on the effects of thermal barrier coating on diesel engine combustion and emission characteristics. They done a mathematic model projected by taking the TBC material parameters into description, which is applied to explore the effects of TBC on engine combustion and emissions. Details of the combustion process was analyzed for the coated and uncoated engines underneath both low and high load conditions.As a outcome TBC shows the exhaust temperature at EVO increases obviously as engine load increases, outcomeing in more exhaust losses.. Soot emission can be greatly reduced with TBC, owing to the improved in-cylinder temperature, accompanying with more NOx emission, but still within accepfigrange. A redistribution of temperature region can be found with TBC. TBC gives significant thermal preservation effect on the rich mixture region due to higher temperature increase rate and the squish region due to higher volume ratio.

Gnanamoorthi Venkadesan. [23] Experimented Investigation of Al2O3/8YSZ and CeO2/8YSZ Plasma Sprayed Thermal Barrier Coating on Diesel Engine. They procced taking aluminium oxide/yttria stabilized zirconia (20%Al2O3 /80%8YSZ) and ceria/yttria stabilized zirconia (20%CeO2 /80%8YSZ) were coated from side to side atmospheric plasma spray technique (APS) as thermal barrier coating (TBC) over CoNiCrAlY bond coat on aluminium alloy (Al-13%Si) substrate piston crown material and their thermal cycling behavior were studied experimentally. Thermal cycle test of both samples were conducted at 800˚C. Micro structural, phase and elemental analysis of the TBC coatings were experimentally investigated by them. The performance, combustion and emission characteristics of Al2O3/8YSZ, CeO2/8YSZ TBC coated and uncoated standard diesel engine were experimentally investigated. As a outcome found that CeO2/8YSZ based TBC has an excellent thermal cycling behavior in comparison to the Al2O3/8YSZ based TBC. The spoliation of the Al2O3/8YSZ TBC occurred mainly due to the arrangement of thermally grown oxide (TGO), and growth of residual stresses at top coating and bond coating interface. The experimental outcomes also revealed that the increase of brake thermal efficiency and reduction of specific fuel consumption for both TBC coated engine. supplementary reduction of HC, CO and smoke and increase of NOx emission were recorded for both TBC coated engine compared to the standard diesel engine.

Stress Distribution & Fatigue Analysis

Kumar. M, *et al.* [24] Investigated Different Thermal Barrier Coatings on Modified Piston. Here they proceed with considering raise the performance of the engine by TBC and to decreasing the heat lost to cooling water and also to increase the swirl for better ignition of Bio-diesel. It was mainly focusing on structural and thermal analysis of TBC coated piston. Design using Solid works and optimization of helical grooves using ANSYS software packages. Various tests were carried out on the designed model with regards temperature, stress and deformation. Yttria-stabilized zirconia (YSZ) coating is comparable to 4mm alumina and 1mm coating in terms of preventing the temperature. AS a outcome found that the deformation increases as the thickness increases. The stress was decreases as the thickness increases. The deformation of 0.5 mm thickness ysz coating material is comparably quite similar to the other 0.5 mm thickness of other coating material. The stress due 0.5 mm thickness ysz coating material is very low as compare to the other coating material of the same thickness.

Tadeusz Hejwowsk. [25] Studied on Comparative study of thermal barrier coatings for internal combustion engine. They investigated into the thermal fatigue resistance of thermal barrier coatings (TBC). Two groups of double-layered thermal barrier coatings (TBC) were investigated: plasma sprayed with ZrO_2-8%Y_2O_3, Al_2O_3-40%TiO_2 or Al_2O_3-40%ZrO_2 top coats and powder flame sprayed with ZrO_2-30%CaO, Al_2O_3-40%TiO_2 and Al_2O_3-30%MgO. The extent of TBC weakening experienced in thermal fatigue test was evaluated in the erosion test and SEM examinations. Flame sprayed coatings were found more prone to damage than plasma sprayed ones. The highest thermal fatigue resistance revealed TBC plasma sprayed with PSZ. Thermal growth of oxides at the top coat interface and the decomposition of Al_2O_3-40%TiO_2 were found to be important dilapidation mechanisms leading to the spallation of coatings in the diesel engine and the petrol engine exploitation test.

G.H. Farrahi *et al*. [26] Investigated Coating thickness effect on stress distribution of coated cylinder head considering residual stress. They considered the coating thickness effect on the stress distribution of a coated cylinder head. A typical thermal barrier coating was functional on a diesel engine cylinder head. The residual stress which occurred during the plasma thermal spraying was also considered. The coating system consisted of two layers; a metallic bond coat and a ceramic top coat. The bond coat thickness was considered as 50 to 250 µm and the top coat thickness was considered as 200 to 800 µm. As a outcome found that the temperature variation increases from 66 to 96°C. FE outcomes demonstrates that the conservative value for the TBC thickness is 1.1 mm in the diesel engine cylinder.. Having analyzed various BC and TC thicknesses by the FE method, the optimized thickness values can be considered as 250 and 500 µm for the BC and TC layers, correspondingly

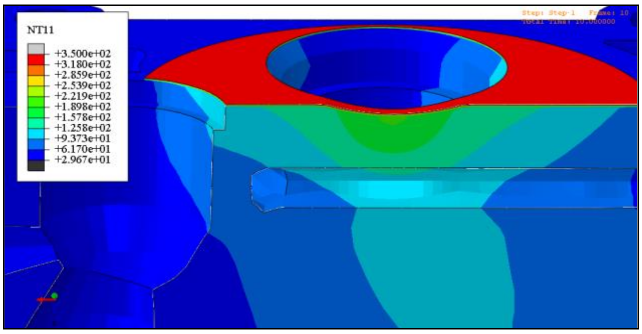

Fig 1: The temperature allocation through the thickness (at the valve bridge of the coated cylinder head) below thermal loadings.

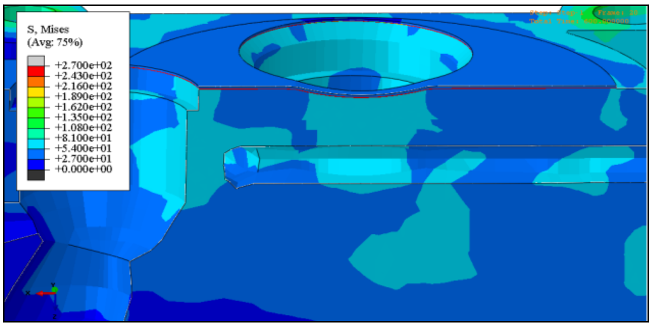

Fig 2: The Von-Mises stress allocation through the thickness at the valve suspension bridge of the coated cylinder head below the thermal spraying process.

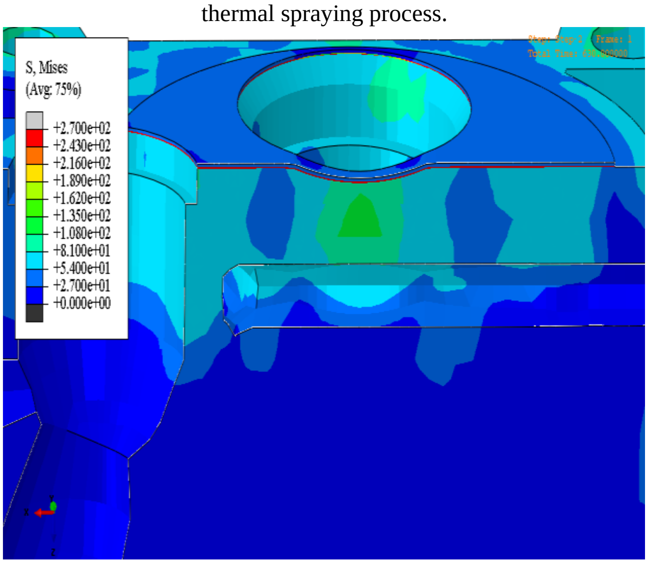

Fig 3: The Von-Mises stress allocation through the thickness (at the valve bridge of the coated cylinder head) under the thermal spraying process plus cyclic thermo mechanical loadings.

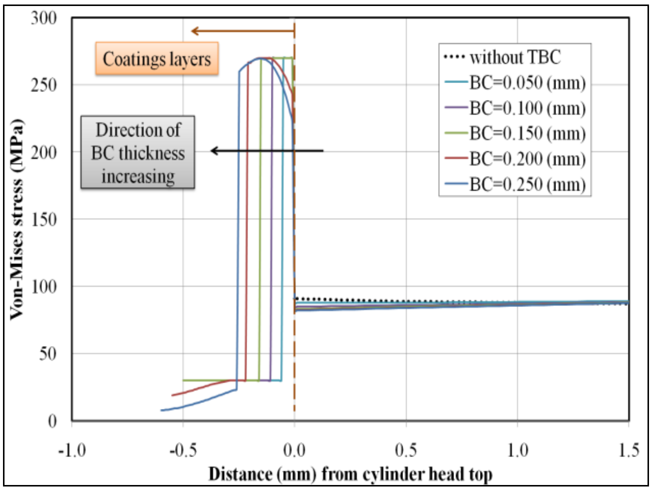

Fig 4: The Von-Mises stress allocation through the thickness (at the valve bridge of the coated cylinder head) for various BC thicknesses.

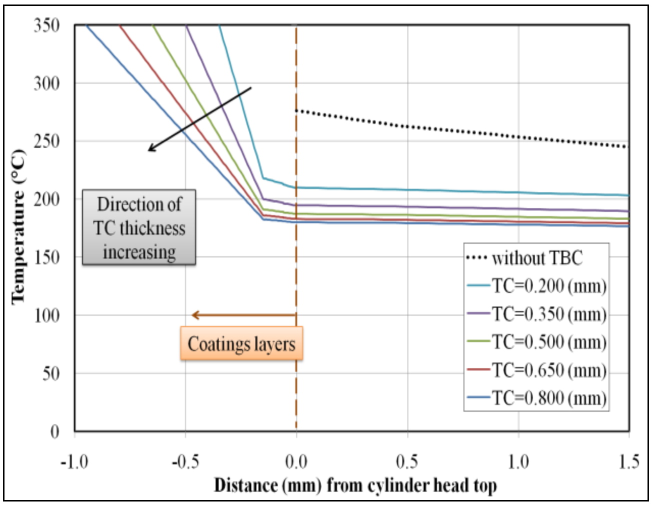

Fig 5: The Temperature allocation through the thickness (at the valve bridge of the coated cylinder head) for various TC thicknesses.

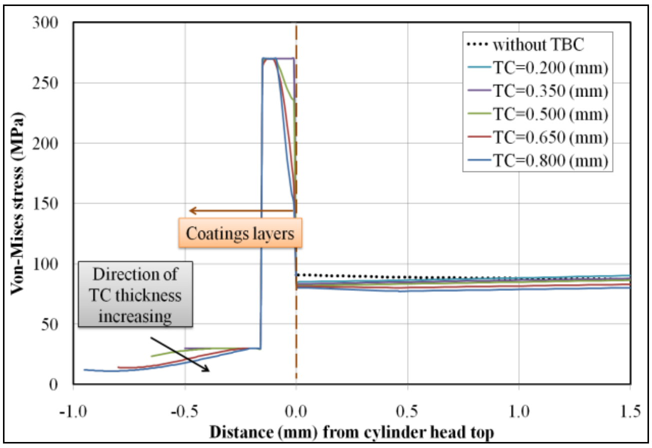

Fig6: The Von-Mises stress allocation through the thickness (at the valve bridge of the coated cylinder head) for various TC thickness.

Muhammet Cerit *et al.* [27] Investigated temperature and thermal stress analyses of a ceramic-coated aluminum alloy piston used in a diesel engine. They determined both temperature and thermal stress allocations in a plasma sprayed magnesia-stabilized zirconia coating on an aluminum piston crown to improve the performance of a diesel engine. Effects of the coating thickness on temperature and thermal stress distribution are investigated, including comparisons with outcomes from an uncoated piston by means of the fem. Temperature and thermal stress analyses are performed for various coating thicknesses from 0.2 to 1.6 mm excluding the bond coat layer. As a outcome they got Temperature at the coated surface is significantly higher than that of the uncoated piston. It was observed that the coating surface temperature increases with coating thickness by decreasing rate. enlarge in the maximum temperature according to the uncoated piston is 64.3% for 1.0 mm thick coating. The normal stress on the coated surface decreases with increasing coating thickness. The numerical simulations clearly show that temperature and thermal stress distribution are a function of coating thickness. As outcome they found that the coating thicknesses, the highest temperature appeared at the crown center and on the edges of the bowl rim on the top surface of the coating and on the piston surface. The temperature at the surface of the coated region was drastically higher than that of the uncoated piston surface. Increase in the maximum temperature at the crown center, compared with the uncoated piston, is 32.7%,55.8%, 72.5% and 84.8% for 0.4 mm, 0.8 mm, 1.2 mm and 1.6 mm thick coating, respectively.

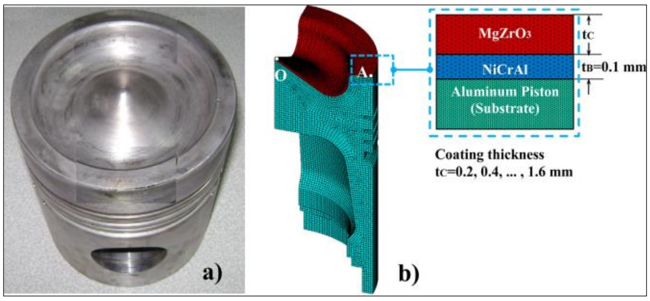

Fig7

Conclusions

In this article, effects of the TBC system on the engine performance and the components duration are reviewed in diesel engine applications considering the parameters like Emissions, fuel consumption,Engine Efficiency, Durability & Stress Distribution & Fatigue Analysis. As a outcome using the plasma thermal spray method proper type of the coating system could be created from two layers of coatings ;like Al2O3/8YSZ and CeO2/8YSZ.Also the fuel utilization reduces, the engine power and the combustion efficiency increases, pollution contents decrease, and the fatigue lifetime of engine components such as the cylinder head and the piston improves due to the reduction of in the surface temperature and also the reduction of the temperature gradient and thermo-mechanical stresses of the substrate.

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