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APPLICATION OF ENERGY EFFICIENT COMPOSITE MATERIAL IN I C ENGINE COMBUSTION CHAMBER: A TECHNICAL REVIEW

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Abstract

Higher demands on emission norms, revolt fuel prices, more precise requirements in the field of the vehicle emissions increasing the pressure on the engine manufacturers to utilise technologies which contribute to a reduction in the emissions and require internal combustion engines to be optimized with respect to their frictional losses and wear. In this study, a complete literatures review of ceramic coating (TBCs) applications in Internal combustion engines Chamber performed to select a proper type and to find coating effects. The Thermal Barrier coating technique has effects on the brake specific fuel consumption, brake power and the Emission characteristic, pollution contents and the Thermal fatigue lifetime of engine components. By using plasma thermal spray method there are several benefits by applying ceramic layers on the combustion chamber, including the piston, the cylinder head, the cylinder block, and intake and exhaust valves. In this article, Literature survey carried out on the basis of reference books, conference volume and Research paper. The details about coating materials, coating methods and researcher results and their conclusions are discussed in depth with facts and figure based on presented articles.

***Keywords**: TBC_S, piston head, Diesel engine*

I. Introduction

The energy balance analysis is recognized as a useful method for aiding the characterization of the performance and efficiency of internal combustion (IC) engines. As there is a high amount of heat loss in atmosphere due to which the efficiency is lower for the standard engine. From the total heat energy of the fuel offered by diesel engine about one-third goes to the coolant, about one-third to the exhaust and only remaining one-third of energy is available as useful power output. Theoretically if the heat rejected could be reduced, then the thermal efficiency would be improved, at least up to the limit set by the second law of thermodynamics. Low Heat Rejection engines aim to do this by reducing the heat lost to the coolant. The idea of a low heat rejection engine (Adiabatic engine) was extensively developed in the 1980s due to its potential in improving engine thermal efficiency via reducing the heat losses. From the first law of thermodynamics, it can be expected that any retained energy by reducing heat losses through the chamber walls can be converted to useful work and consequently improve the fuel conversion efficiency. In this study, the LHR operating condition is implemented by increasing the engine coolant temperature. The LHR engine has been conceived basically to improve fuel economy by eliminating the conventional cooling system and converting part of the increased exhaust energy into shaft work using the turbocharged system. A large number of studies on performance, structure and durability of the Thermal Barrier Coated (LHR) engine have been carried out the investigations have been concluded that insulation reduces heat transfer, improves thermal efficiency, and increases energy availability in the exhaust . An attempt will be made here to investigate and review the previous studies to look into future possibilities of the LHR engine from the viewpoint of combustion heat transfer and emission. There is one possible solution to reduce such problem i.e., converting the conventional CI engine in to the LHR engine.

TBC Materials:

Thermal barrier coatings (TBCs) are highly advanced material systems mostly applied to metallic surfaces, such as gas turbine or aero-engine parts which operate at elevated temperatures, as a form of exhaust heat management [3]. The purpose of these coatings is to insulate components from large and prolonged heat loads by using thermally insulating materials which can sustain an appreciable temperature difference between the load-bearing alloys and the coating surface. The coatings of insulation materials used in the LHR engine must have a high temperature strength, high expansion coefficient, low friction characteristics, good thermal shock resistance, light weight and durability [18].The term ceramic now covers a very wide range of materials including building materials sanitary were, table, refractories, dielectrics, magnetic ceramics, insulators, etc. Materials that are used for engineering in its mechanical sense can be considered to be the stronger ones, usually specially developed for their fine grain size and high density. They can be divided conveniently into two groups: oxides and non-oxides. In the former group fall traditional Porcelains, alumina, magnesia and other refractory oxides. In the latter are silicon carbide, silicon nitride, boron carbide, boron nitride, molybdenum disilicide and other such compounds, of which the first three are probably the most important. The ceramic materials of principal interest for heat engine applications are silicon nitride, silicon carbide, zirconia and lithium aluminum Silicate (LAS). Although it has good thermal properties, LAS has very poor mechanical properties, so its use is limited to non-structural components. It's extremely low thermal expansion and excellent thermal shock resistance make it ideal for application like catalytic convertors, regenerators and flow separator housing where one side of the component may reach temperatures several hundred degrees higher than the other side. Although it is of higher density than Sic or Si3N4, there is still some uncertainty about its high temperature performance. The conditions for reversibility of the transformation toughening reaction may not be understood well enough yet to predict behavior under dynamic or repeated stress. However zirconia is an excellent insulator and has a thermal expansion equal to 80 % that of cast iron making it a suitable choice for a coating material for cylinder linear, piston caps and intake ports. In these its low coefficient of friction and good wear/corrosion resistance can also be exploited. Silicon carbide and silicon nitride are by far the materials most often considered for components to be subjected to the most severe thermal environments. Their superior room temperature and high temperature strength and oxidation resistance make them principal candidates for rotors and stators and rators and numerous other engine components. The ceramic coating which can also be considered for engine components are hot pressed silicon carbide (HPSC), hot pressed silicon nitride (HPSN) and stabilized zirconia (SZ). Fully stabilized zirconia coating performs very poorly in thermal cycling test. Yttria is used to partially stabilized zirconia, thus raising its mechanical strength and it resist to thermal shock and thermal fatigue.

Metal Coatings

Metal coatings are used to prevent ferrous metals from corroding and also to improve the appearance of all metals. Each type of coating accomplishes a different goal and has its own appearance.

- Anodizing

While anodizing is most common with aluminum, it can also be used on other metals such as titanium and zinc. However, ferrous metals cannot be anodized because the iron oxide, or rust, flakes off, which causes the anodized layer to also flake off. When aluminum is exposed to oxygen, a layer of aluminum oxide is formed on the surface of the metal. Anodizing effectively increases the thickness of this aluminum oxide layer, which makes it more resistant to corrosion. To further increase the durability and corrosion resistance, a clear sealant can be used. The anodizing process also provides better adhesion for paints and other finishes. Finally, the anodized aluminum can be dyed prior to sealing to provide a colored aluminum.

- Galvanizing

Galvanizing is a process by which a layer of zinc is applied to a ferrous metal to prevent corrosion. The process most-commonly refers to hot-dip galvanizing, where a piece of steel is dipped into a bath of molten zinc. The zinc adheres to the steel and immediately reacts with oxygen in the air to form a very strong zinc oxide layer, which prevents corrosion of the steel below. The zinc and steel form a metallurgical bond so the coating will not flake off. The finish is a dull gray and has a crystalline appearance. The galvanized steel can be painted to achieve a specific color. When galvanized metal is welded, the weld and exposed steel must be coated with a special zinc paint to prevent the joint from rusting since the galvanized coating has been removed.

- Electroplating

Electric current is used to adhere a solution of (generally) cadmium and chromium to a metal. Nickel plating is a form of electroplating. One problem with electroplating is that it is difficult to achieve a uniform thickness on a piece. The plating resists corrosion and provides a pleasing appearance.

- Powder Coatings

A dry powder is electro statically applied to a metal part. The part is then cured under heat of about 200 degrees Fahrenheit, which produces a very consistent and pleasing appearance. Powder coatings are generally more environmentally friendly than paints since solvents are not require. Powder coatings come in an unlimited range of colors.

- Porcelain Enamel Coatings

Most commonly seen in cast-iron cookware, enamel coatings provide a smooth and consistent coating that is resistant to stains and scratches. The coating also prevents corrosion. Since they are resistant to stains, enamel coatings provide easy cleaning for surfaces prone to graffiti. Porcelain enamels are used most often on toilet-room partitions.

TBC Technique use for development of an Adiabatic Engine

TBCs are a type of Green Technology that is becoming increasingly popular within the automotive industry due to their effectiveness in reducing heat loss within an engine. This reduced heat loss allows engines to use less energy to maintain their desired temperature, thereby increasing fuel efficiency. TBC process has a unique densification process that allows us to seal the porosity of the TBCs which decreases their rate of absorption, allowing our TBCs to outperform and outlast our competition.

Ceramic coatings which are applied to reduce heat transfer are divided into two groups. Generally, up to 0.5mm coatings named as thin coatings and thick coatings are up to 5-6mm. Thin ceramic coatings are used in gas turbines, piston tops, cylinder heads and valves of Otto and diesel engines. At the beginning of ceramic coatings to low heat rejection engines, thick monolithic ceramic coatings were applied to engine parts. Later, it was understood that these coatings are not appropriate for diesel engine operation conditions. There are a lot of types and system for ceramic and other material coatings. Most important ones are;

Thermal spray coating: Plasma spray, wire flame spray and powder flame spray, electrical arc spray, detonation gun technique and high speed oxy fuel system.

Chemical ceramic coating: Sole-gel, slurry, chemical vapors sedimentation, physical vapour sedimentation, hard coating.

Material conglomerations can be avoided by reducing erosion-corrosion, friction-wear, using ceramics as well as improving heat insulation. None the less, these methods are proper for very thin coatings except thermal spray coatings. Thin layer coatings are successfully used in gas turbine industry, coating turbine and stator blades and combustion rooms. For thick layer coatings like diesel engines, plasma spray and flame spray coatings are generally utilized.

- **Thermal spray method**

Thermal spray coating refers to a number of processes in which a substrate is coated to improve functional performance. Many types of coating materials can be applied by thermal spray processes. Coatings can range in thickness from a thousandth of an inch up to an eighth of an inch. Thermal spray coatings have been used to protect parts from wear, abrasion, corrosion, high temperatures, etc. and to build dimensions on undersized parts. Thermal spray coating processes involve the deposition of coatings from a stream of high velocity finely divided particles in a molten or semi-molten state impinging onto the substrate. These processes use fine powdered source material or sometimes metal wire that is molten and broken into fine droplets. The coating gun adds thermal energy to bring the materials to a plastic or molten condition and accelerates these materials at high velocities toward the substrate.

There are several different types of Thermal Spray Coating processes. They differ in how they apply thermal and kinetic energy to the source material, the form of the source material (powder or wire) and the relative velocities and temperatures of the flame. Each process has advantages and disadvantages, and some are optimized for certain types of coatings. Thermal Spray Coatings are applied by Robot for accurate control of coating properties and thickness and for process repeatability. It also relies on advanced process control systems to ensure that the quality of the coatings is optimized. Thermal spray coatings can also be applied by hand controlled guns.

The thermal spray gun provides energy to the coating material particles and transports the coating to the substrate part. Energy can be thermal (heat) or kinetic (velocity). Several different technologies are available:

- **Flame spray method[13]**

Oxy-hydrogen and oxy-acetylene systems are preferred in flame spray coatings and usually refractory oxides which have lower melting point than 2760 C are used in coating with these systems.

Figure Flame Spray Thermal Spray Coating

Before ceramic coatings, a binding layer resistant to high temperature like nickel-chromium should be applied to material surface for preventing oxidation as can be seen in Fig. 3. Otherwise, ceramic coating can't adhere to the surface properly. Coating speed in flame spray method is relatively slow and it changes between 4.4×10^{-5} and 1.13×10^{-3} m/s.

❖ **Resulting Properties**

Following are the resulting properties of flame spray coating

- It shows lower bond strength than newer thermal spray technologies
- Lower density than newer thermal spray technologies
- Good process for soft metal coatings
- Process of choice for certain abradable coatings
- Good process for economical ceramic coatings

- **Plasma spray method[7][10][9][4][10]**

In plasma spraying process, the material to be deposited (feedstock) is typically as a powder, sometimes as a liquid, wire is introduced into the plasma jet, emanating from a plasma torch.

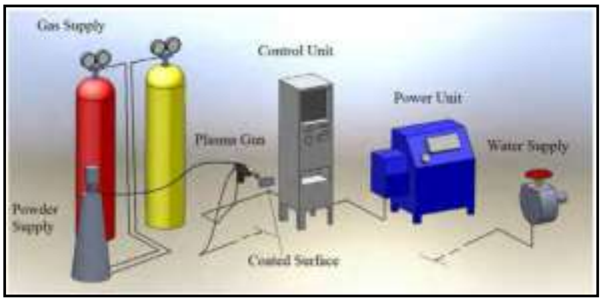

Figure plasma coating system

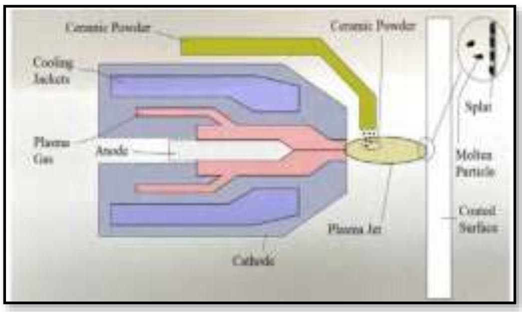

Figure Plasma spray gun

In the jet, where the temperature is on the order of 10,000 K, the material is melted and propelled towards a substrate. There, the molten droplets flatten, rapidly solidify and form a deposit. Commonly, the deposits remain adherent to the substrate as coatings; free-standing parts can also be produced by removing the substrate. There are a large number of technological parameters that influence the interaction of the particles with the plasma jet and the substrate and therefore the deposit properties. Corrosion resistance properties of composite coatings is influenced by porosity which can be adjusted using plasma spraying parameters[27].

These parameters include feedstock type, plasma gas composition and flow rate, energy input; torch offset distance, substrate cooling, etc.

❖ **Resulting Properties[13]**

- Process of choice for coating ceramic and thermal barrier coating materials
- High density to high porosity coatings possible
- Excellent Adhesion
- Very High Bond Strength
- Uniform Coating
- Good oxide ceramic stoichiometry

HVOF – High Velocity Oxygen Fuel Thermal Spray Coating[13]

In spray processes called high velocity oxy-fuel spraying mixture of gaseous or liquid fuel and oxygen is fed into a combustion chamber, where they are ignited and combusted continuously.

The fuels can be gases (hydrogen, methane, propane, propylene, acetylene, natural gas, etc.) or liquids (kerosene, etc.). The jet velocity at the exit of the barrel exceeds the speed of sound. A powder feed stock is injected into the gas stream, which accelerates the powder up to 800 m/s.

The stream of hot gas and powder is directed towards the surface to be coated. The powder partially melts in the stream, and deposits upon the substrate. The resulting coating has low porosity and high bond strength.

The types of coatings that are most widely viewed as being capable of replacing hard chrome plating are the thermal spray technologies, especially high-velocity oxy-fuel (HVOF) thermal spraying. With this process, the coating material, in powder form, is fed into the combustion chamber of a gun where, a fuel, such hydrogen, ethylene or kerosene, is burned with oxygen, and the heated and softened powders are expelled as a spray with the supersonic gases. Powders deposited using HVOF includes pure metals, metal alloys, cermets and certain ceramics and polymers.

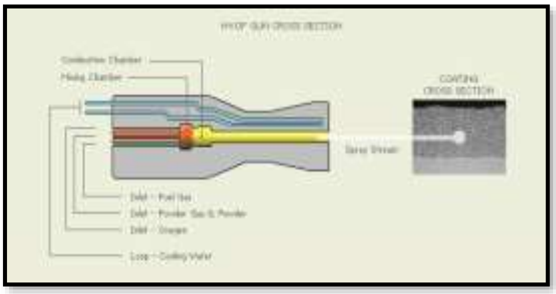

Figure Principle of HVOF Coating

The reason why HVOF is the preferred thermal spray process for chrome replacement is because it produces low porosity (<1%), highly adherent (bond strength > 50MPa) coatings which generally have an oxide content less than 1% even for reactive metals. As a flexible dry-coating technology it avoids high volume waste streams associated with electroplating and provides a choice of coating materials for each application.

The high-velocity oxy-fuel (HVOF) thermal spraying process has shown to be one of the best methods for depositing conventional Cr_3C_2–NiCr feedstock powders, because the hypersonic velocity of the flame shortens the time of interaction between the powder and the flame.

These effects in conjunction with the relatively low temperature (as compared to plasma based techniques) result in less decomposition of the carbide particles during spraying.

❖ **Resulting Properties**

- Process of choice for high quality wear resistant coatings
- Highest density thermal spray coatings
- Outstanding adhesion
- Extremely High Bond Strength
- Uniform Coating
- Excellent Wear Resistance (Carbides)
- Excellent Corrosion Resistance
- Low Application Temperature
- Low Residual Stresses
- Higher Impact Resistance
- Neutral to Compressive Residual Stress (Greater thickness capability)
- Less Chipping & Peeling vs. other Thermal Spray Processes

- **Chemical vapour deposition (CVD coating):**

Chemical vapour deposition (CVD) is a chemical process used to produce high-purity, high-performance solid materials.

(1) Hot wall thermal CVD:

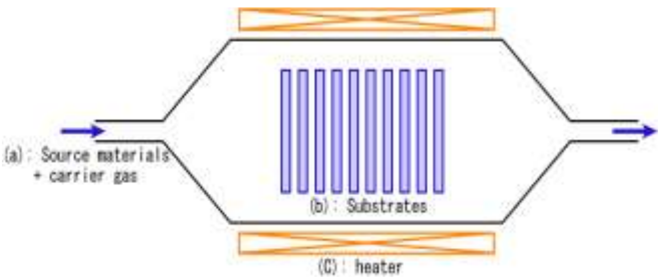

Figure Hot wall thermal CVD

(2) Plasma assisted CVD:

Plasma-Enhanced CVD (PECVD) – CVD process that utilizes plasma to enhance chemical reaction rates of the precursors. The lower temperatures also allow for the deposition of organic coatings, such as plasma polymers, that have been used for nano-particle surface fictionalization.

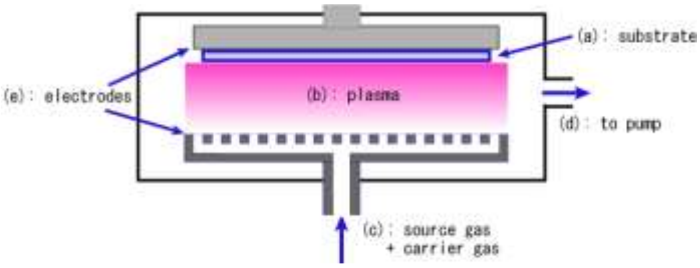

Figure Plasma assisted CVD

- **Physical Vapour Deposition (PVD) method**

Physical vapour deposition (PVD) is a variety of vacuum deposition methods used to deposit thin films by the condensation of a vaporized form of the desired film material onto various work piece surfaces.

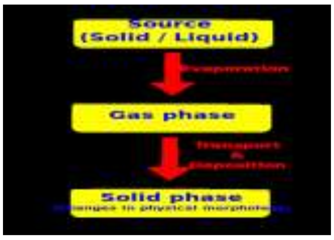

Figure Process of physical vapour deposition

In the present investigation, physical vapour deposition (PVD) sputtering technology is used to influence the wear behavior by thin films within a wide range of mechanical properties. Studies on different coating materials have taken place and emphasize the demand for suitable surfaces. The wear of piston rings is investigated with respect to PVD hard coatings as a surface finish with an adjustable profile of mechanical properties. Therefore, PVD coatings have been deposited, characterized and used in model wear tests for simulating the complex tribological system piston-ring-cylinder.

This tribological system can be seen as an example for mechanical components working under intensive wear conditions over a long period of time. As the investigation shows, PVD hard coatings can reduce wear rates very effectively

High-velocity oxy-fuel (HVOF) thermal spraying[13]

In spray processes called high velocity oxy-fuel spraying mixture of gaseous or liquid fuel and oxygen is fed into a combustion chamber, where they are ignited and combusted continuously.

The fuels can be gases (hydrogen, methane, propane, propylene, acetylene, natural gas, etc.) or liquids (kerosene, etc.). The jet velocity at the exit of the barrel exceeds the speed of sound. A powder feed stock is injected into the gas stream, which accelerates the powder up to 800 m/s. The stream of hot gas and powder is directed towards the surface to be coated.

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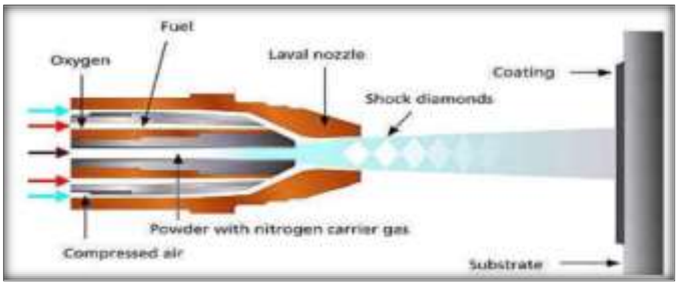

Figure Principle of HVOF Coating

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Advantages of Ceramic Coated engine

When Engine performance of Compression Ignition engine & Spark Ignition engine takes place with ceramic coated engine parts by experiment and finite element analysis, it offers the following advantages:

It show increase the thermal efficiency of the engine.

- ❖ To lower the fuel consumption.
- ❖ Increase the temperature of combustion inside engine cylinder for complete combustion.
- ❖ It show reduce in exhaust gases emission .

- To increase the performance of the engine.
- Durability of engine component increse
- It reduce the friction between engine components.
- Low cetane fuels can be burnt.
- Improvements occur at emissions.
- Waste exhaust gases are used to produce useful shaft work
- Increased effective efficiency,

II. EXISTING LITERATURE

Dhiren Patel, A J Modi, , 2015[1] investigated the performance and emission characteristics of twin cylinder ceramic coated water cooled Diesel engine using blends of diesel and neem bio diesel. In this work they prepared bio -diesel in laboratory from non-edible vegetable oil (neem oil) by transesterification process with methanol, where potassium hydroxide (KOH) was used as a catalyst and Combustion chamber inner wall. Air Plasma spray Technology was used to coat Magnesium Zirconate on inner wall of Combustion chamber, Piston crown and valve faces. Results Shows that brake thermal efficiency of the Lower Heat Rejection engine is found to be higher by 11-13% and brake specific fuel consumption was 7-12% lower in LHR engine than that of the Standard engine at extreme load condition.

R. G. Telrandhe, Parag C. Thanare , 2015[2] investigated and analyze the thermal stress distribution of piston, piston rings at the real engine condition during combustion process. With application of the thermal barrier coating results indicate on piston crown the thermal stress 10 -15% decreases because low thermal conductivity of coating material Magnesium Zirconate ($MgZrO_3$**)** & Titanium Alloys

K. Komali, Nagarjuna Jana , 2015**[3]** enhanced piston model using ANSYS for thermal distribution in functionally Graded Material Coated Piston. Temperature distribution on the piston's top surface and substrate surface is examined by using finite element based software called ANSYS. The functionally graded material whose properties are varied along the thickness of the coating is considered. The FGM is actually a layer of ceramic consisting of zirconium with different proportions of nickel-chromium aluminum alloy bond coat applied along its thickness using the HVOF process.

G. Sivakumar, S. Senthil Kumar, 2014[4] investigated the effect of air plasma spraying technique on the piston crown surface to form a 100 micron Yttria Stabilized Zirconia thin TBC coating layer. Result indicates heat loss to the cooling system is reduced up to 5–10%

Brake Specific Fuel Consumption is reduced by 3.38% and 28.59% at high load and 25% of the full load conditions respectively. Particulate Emissions in the exhaust were also reduced by 35.27% in the Thermal Barrier coated engine, where CO emission is reduced by 2.7% and CO2 emission increased by 5.27%.

Ekrem Buyukkaya, Muhammet Cerit, 2007[5] analysed the thermal analysis of a ceramic coating MgO-ZrO2 Compression ignition engine piston by 3-D finite element method and investigated thermal analyses of uncoated

diesel piston made of aluminium silicon alloy and steel. A Ceramic coating has the capacity to give maximum thermal efficiency, improves combustion and reduces emissions. Compared to conventional materials, Ceramics used as thermal barrier coating have more thermal durability than metals and display improved wear characteristics. It was observed that Piston is coated with a 350 μm thickness of MgZrO3 over a 150 μm thickness of NiCrAl bond coat shows better result with less thermal conductivity improved by 48% for AlSi alloy and 35% in case of steel.

Y. Sureshbabu, P. Ashoka Varthanan, 2014[6] recognized that the catalyst coating on the piston, combustion chamber gives the maximum brake thermal efficiency. This study aims to identify the best coating material for spark ignition engine. Among the different catalysts investigated, copper is very effective in reducing HC and CO emissions for SI engines and hence proved that copper coating is most suitable for SI engines. In future copper coating thickness will be optimized for better

results.

Debasish Das, Gautam Majumdar, Rajat Shubra Sen, B. B. Ghosh, 2013[7] coated three piston crowns with Al_2O_3 as bond coat of 100μm thickness & Partially Stabilized Zirconia with top coat of 250μm, 350μm, 450μm respectively by Plasma spray coating technique. Performance shows that on the application PSZ as a ceramic coating increased oxidation, which increases the generation of CO2. It has been observed that coated piston engine increases the cylinder pressure and better heat release rate due to complete combustion. Partially stabilized Zirconia can act like an insulator and prevent heat rejection from the engine.

M Azadi, M. Baloo, 2013[8] studied effect of thermal barrier coating on diesel engine, it shows that performance and emissions characteristic of engine improve. In this presented paper they compare the coated NiCrAlY with 150 microns thickness and another layer made of ZrO2-8%Y2O3 with 300 microns thickness by using the plasma thermal spray method with uncoated engine. Hence they examined that thermal efficiency increases & emission parameter is also improved. Brake Specific Fuel consumption decreased by 12% with increase in Engine lifetime, Engine power, Valves lifetime compared with the uncoated piston is 20%, 10% and 300% respectively.

Vinay Kumar Domakonda, Ravi Kumar Puli, 2012[9] presented the paper that show effect of ceramic material on performance parameter of engine, heat transfer characteristics, combustion characteristics and emission characteristics. Research on low heat rejection engines was carried out , it's show increase in the in-cylinder temperatures helped in better release of energy in the case of biodiesel fuels thereby reducing emissions at almost the same performance as the diesel fuel. The reduction of heat loss from the combustion chamber of diesel engines improves fuel economy by 3% to 4%.

Helmisyah Ahmad Jalaludin, Shahrir Abdullah, Mariyam Jameelah Ghazali, Bulan Abdullah, Nik Rosli Abdullah 2012[10] carried out test experimental investigation on ceramic coated piston crown with CNG DI engine with bonding layer NiCrAl and ceramic based yttria partially stabilized zirconia were air plasma sprayed onto AC8A aluminum alloy CNGDI piston crowns and normal CamPro piston crowns in order to reduce thermal distortion. The performance of the coating against high temperature was tested using a burner rig and temperatures on the top of piston crown and piston underside were measured. Hence, they concluded that the YPSZ/ NiCrAl coated CNGDI piston crown experienced the least heat fluxes than the uncoated piston crowns.

Ramaswamy P, Seetharamu S, Verma K, Raman N, Rao K.[11] examined the effect of atmospheric plasma spraying technique on the piston crown surface to form a 100 micron NiCrAlY thin TBC bond coating layer and 260 micron ZrO2–8%Y2O3 top coating layer. Result shows BSFC decreases by 6–7% for YSZ in the TBC coated engine.

Parlak A, Yasar H, Eldogan O[12] examined the effect of Atmospheric plasma spraying technique on Cylinder head and valve with CaO–ZrO2 (0.35 mm) under Variable loads and constant speed result shows BSFC decreases by 6%

T. Karthikeya Sharma[13] investigates the effects of using argon (Ar) gas to mitigate the spark ignition engine intake air to enhance the performance and cut down the emissions mainly nitrogen oxides result Shows A 55% reduction in NOx emissions was observed in the engine emissions by the replacement of N2 by Ar and increase in air fuel ratio.

Ekrem Buyukkaya, Muhammet Cerit, 2007[14] carried out both temperature and thermal stress distributions to improve the performance of a diesel engine. He modified the standard baseline engine with Magnesia-stabilized zirconia coating on an aluminum piston using different coating thickness. Concluded with increases in Thermal efficiency of the engine. Identified 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

Hitesh Buhecha et. Al[15]. study effect on performance and emissions results of LPG fuelled Engine with Alumina coating.he modified baseline engine with Coating of Al_2O_3 on SI engine, thickness around 200 µm and used LPG as fuel and found that BSFC is 29% lower at 50% loads and 12% reduces at maximum loads.CO is reduced maximum 0.03% at 50% load & at full loads it rescues 0.02% .

Susumu Uozato et. Al[16] investigated the wear and corrosion resistance with newly developed ferrous powder, Fe–C–Ni–Cr–Cu–V–B is using particle sizes of 200–300 µm using Rota-Plasma spray coating , its showed excellent wear performance compared with liner bulk materials currently used in actual engines and Weight loss of the coating was about 2%.

Hanbey Hazar[17] performed test on the uncoated engine and compared with Coated engine with modification of Al_2O_3-TiO_2 thickness of 250 µm over 50 µm thickness of NiAl bond coat using plasma spray method. He conclude that improve in engine power and specific fuel consumption, as well as significant improvements in exhaust gas emissions.

D. N. Assanis[18] described the application of a computer simulation of the turbocharged turbo compound diesel engine system to study the effect of combustion chamber insulation on the performance of various LHR system configurations he conclude that coating of sprayed zirconia can result in a substantial (43%) reduction in heat loss. The lower the thermal conductivity and the lower the thermal capacity of the material, the higher the wall surface temperature variations, the smaller the degradation in volumetric efficiency and thus the better the thermal efficiency of the overall system.

Hitesh Buhecha et. Al[19] study effect on performance and emissions of LPG fuelled Engine with Alumina coating. Modified LPG fuel engine with thickness around 200 µm Al_2O_3 on SI engine shows thermal Efficiency increases & Emission result is also improved. it conclude that BSFC is 29% lower at 50% loads and 12% reduces at maximum loads.CO is reduced maximum 0.03% at 50% load & at full loads it rescues 0.02% .

K.Thiruselvam[20] Study of effect of thermal barrier coating in internal combustion engine. TBC coating in cylinder liner and piston. SFC for all test fuels decreases in coated condition Gasoline in ceramic coated engine showed 3.8% rise in break thermal efficiency at lower loads and peaks to 6% at maximum load.

Cengiz Oner et. al.[21] The wear behaviors of the engine with CrN coated cylinder and with uncoated, cast iron cylinder were compared. Chromium nitride (CrN) coatings doing with physical vapor deposition (PVD) process Improved hardness, microstructure and roughness values of the surface present a longer life for the cylinder.

III. CONCLUSION

Research regarding any of the subject or course can be made possible only through the knowledge of previous work related to the same branch. So, following work carried out by the eminent personalities will always be the stepping-stone for the future revelations. Required deep knowledge before carrying research work can be made well by discussing the previous work carried out by the researchers in the various fields which are related to topic.

Thermal Barrier coating material continues to be successfully applied for Gas Turbine engine used in transportation , Aerospace and IGT applications. Material improved effiecieny, power, reliability and process versatility give the product a long history of success.

Y_2O_3 stabilized ZrO_2 ceramics and MgZrO3 can be an air plasma-sprayed with APS Technology application hardware to meet engineered design coating criteria using either mass flow control or volumetric flow meters. By changing parameters, it has been demonstrated that coatings can be altered with great latitude while maintaining efficiency.

These articles are introduced, together with a discussion of the major challenges to improved coating development, Combustion chamber Analysis with mechanical parameter and effect of piston crown coating on the performance of engine thus following conclusions have been made. This chapter presents the detailed literature review on

Coating materials properties such as low thermal conductivity, high melting point, resistance to sintering, a demonstrated manufacturing capability for depositing it with constant composition, and long life in the resulting TBCs

Coating materials such as Nickel chromium and alloys has Corrosion resistance, Melting point, Hardness and prevents scaling on carbon and low alloy steels.

There are some of the areas where more work on the experimental side can be done to for adequate methods for measuring and characterizing the mechanical and thermal properties of coatings at high temperatures, improve the performance of an I.C. Engine by nanostructure APS coating, oxidation behaviour under real operating conditions thus thermal efficiency increase.

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