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# Thermal and Structural Analysis of Single and Multi- Layer Ceramic Coated Piston Head in Diesel Engine

***Ashik M Ninan*[1], *R. Soundararajan*[2]**

[1]*P. G Student, Department of Mechanical Engineering, Mahendra Engineering College, Namakkal, Tamilnadu, India*
[2]*Assistant Professor, Department of Mechanical Engineering, Mahendra Engineering College, Namakkal, Tamilnadu, India*

**ABSTRACT**

The main objective of this paper is to increase the thermal efficiency of an IC engine by the application of coating ceramic materials on the pistons top surface. And the steady state thermal efficiency and static structural analysis are done by using the software ANSYS Workbench. By coating the ceramic material on the piston head the temperature inside the combustion chamber is increased. And as a result the fuel burning rate will be increased. The rate of heat transfer by conduction and convection are reduced because of the low thermal conductivity of ceramic coating materials. Because of the application of thermal barrier coating, we can increase the thermal efficiency of the piston. TBC reduces heat rejection from the engine. It also protects piston from corrosion attack, thermal stress, high heat emissions and it reduces heat flux into the piston and fuel consumption. The amount of fuel used for combustion is reduced by the reduction of partial combustion of fuel. TBC allows the efficient use of low quality fuels by making the piston temperature much higher than uncoated one due to which proper combustion of fuel occurs. In the present study both temperature and stress distribution in single and multi-layered coatings using Aluminium Oxide (Al2O3), Chromium Carbide (Cr3C2), Silicon Dioxide (SiO2), Nickel Chromium (NiCr), and Titanate (TiO3), on A390 cast alloy piston head are done under various thickness to improve the performance of diesel engine. And the result were compared with uncoated piston.

**Keywords:** Thermal Barrier Coating (TBC), Low Heat Rejection Engine (LHR Engine), Internal Combustion Engine (ICE), Finite Element Analysis (FEA), Computer Aided Design (CAD), Nano Ceramics, Steady State Thermal Analysis, Static Structural Analysis, Diesel Engine Piston, Thermal Stress, Ceramic Coating Thickness.

## 1. Introduction

The project deals with the use of thermal barrier coating on the head of the piston so that the temperature inside the chamber increases. The aim is to convert the conventional engine into low heat rejection engine. Thermal barrier coatings (TBCs) are commonly applied to substrate surfaces to insulate them thermally so as to allow it for high temperature operations. The desire to increase thermal efficiency or reduce fuel consumption of engines makes it tempting to adopt higher compression ratios, in particular for diesel engines, and reduced in cylinder heat rejection. Coating of the diesel engine pistons is one of the thermal engineering application of TBCs among others. Thermal Barrier Coatings are applied to insulate the combustion chamber components or selected surfaces like the piston crown. Heat rejection is then reduced in the cylinder and the metallic surfaces are protected from thermal fatigue, especially from power and exhaust strokes of the diesel engine cycles. The coating is a nano ceramic-based material that has low thermal conductivity and good strength and that is capable of enduring higher temperatures than metals. The main purpose of this is to raise the temperature of the piston head surface during the expansion stroke, thereby decreasing the temperature difference between the wall and the gas to reduce heat transfer. Some of the additional heat energy in the cylinder and piston top surface can be converted and used to increase power and efficiency. The Low Heat Rejection Engine (LHR Engine) is an advanced technology, which minimizes heat loss to the coolant by providing heat resistance in the heat flow to the coolant. The use of thermal barrier coating in the automotive and automobile industries has been found to yield a significant effect on the efficiency of engines. The challenge for Automobile is the present emission norms that demands engine for green environment with high performance and low HC and CO emission. The depletion of fossil fuel resources at a faster rate in the present world of economic competitiveness is generating an essential demand for increase in the efficiency of internal combustion engines.

## 2. Literature Survey

From the literature review, it is observed that there was lots of studies has been done on the IC engine piston coated with thermal barrier coating by changing the designing of piston or by changing the coating material but only few studies based on the coating design have been carried out. The main reason of this analysis is to determine the maximum temperature distribution of the piston by using the ceramic coatings having holes on its surface which improve the piston temperature for combustion. Thermal Barrier Coatings (TBC) in internal combustion engine have so many advantages such as improved thermal efficiency and combustion, reduction in weight by eliminating cooling systems, etc. however, practical problems are faced in implementing these thermal barrier coatings in internal combustion engines. TBC must also withstand wear and tear. The disadvantage of the TBC method is that NOx emission is increased.

**a) Thermal Analysis Of Ceramic Coated Piston Head In Diesel Engine Nishant Varshney, Divyansh Mishra, Pawan Kumar Agrahri, Subhash Gupta, Chandan B.B.**

The temperature distributions in plasma sprayed Yttria Stabilized Zirconia (YSZ) and Magnesia Stabilized Zirconia (MgZrO3) thermal barrier coating on an aluminium alloy piston crown to raise the potential of a diesel engine. The influence of ceramic coating thickness on temperature variations are studied by finite element method using ANSYS. The temperature distribution analyses were conducted for the ceramic coating thickness of 0.3mm over the piston crown surface. The results of the piston coated with two different coatings were analysed. It is observed that, the peak exterior surface temperature of the ceramic piston with the material MgZrO3 is increased by 32% and 20% for the piston coated with Yttria Stabilized Zirconia compared with conventional aluminium alloy piston.

**b) Influence of Ceramic Coating On Piston Surface In I.C Engine. V. Mohan, N. Surya, D. Srinu**.

Aim of this work is to improve the structural analysis coated with ceramic layer on surface of the piston. Generally cast steel material is used for piston in I C engines; it can be withstanding the structural and thermal analysis, and producing the power from the combustion. In this work the ceramic material like zirconium and silicon coating is applied on the surface of piston with 0.4 mm thickness in order to get better results and testing the piston using ANSYS software analyze the structural analysis. The results obtained in this work were deformation, stress, strain and safety factor, the obtained results were comparable with the steel material.

**c) Material Coating Optimization And Thermal Analysis Of A Four Stroke C I Engine Piston P.V. Srikanth B.V.V Prasada Rao, K.Mohan Laxmi, Prof.N.HariBabu.**

Mesut Durat discuss about the study of designing pistons of a SI engine with partially thermal barrier coatings which possess low heat conductance properties have a great potential to improve performance and to reduce unburned emissions at idle and partially load conditions. Low heat conductance of ceramic coatings on the top surface of the piston near the flame quenching area is able to increase the temperature from 18% to 48%. However, the degree of thermal insulation on the top surface is constrained with the combustion knocking since the temperature increases extremely at this region. The phenomena are especially observed at full load conditions.

## 3. Basic Concepts

### a) Hot Corrosion

Corrosion is a naturally occurring process, which converts the refined metal to a more chemically-stable form, such as its oxides, hydroxides, or sulfides. It is the gradual destruction of materials (usually metals) by the chemical and/or electrochemical reaction with their environment. Corrosion engineering is the field dedicated to controlling and stopping corrosion in metals.

### b) Types of Corrosion in Engine

Engine sections hot corrosion is the most serious form of corrosion experienced by the turbine section components. To better understand the hot corrosion process, it is useful to first study about oxidation. Oxidation is the chemical reaction occurring at high temperatures between a component and the oxygen in its surrounding gaseous environment. Chances of Oxidation of engine section components are relatively easy to predict and measures can be taken to control it since it primarily involves relatively simple metal/oxygen reactions. The oxidation rate increases with increase in temperature. Hot corrosion is another form of accelerated oxidation that is produced by the chemical reaction between a component and molten salts deposited on its surface. Hot corrosion comprises of a complex series of chemical reactions, making corrosion rates very difficult to predict. Sodium sulfate is usually the primary component of the deposit and degradation becomes more severe with increasing concentration levels of contaminants such as sodium, potassium, vanadium, sulfur, chlorine, fluorine, and lead. The rate and mechanism of hot corrosion attack is influenced by change in temperature. There are two types of hot corrosion. They are Type I or high temperature hot corrosion, which occurs at a temperature range of 730 to 950°C. And Type II or low temperature hot corrosion occurs at a temperature range of 550 to 730°C. These types of hot corrosion attacks feature distinct mechanisms and exhibit unique features.

### c) Coating

A coating is a kind of covering that is applied to the surface of an object, usually it is referred as the substrate. The purpose of applying this coating may be decorative, functional, or both. The coating itself may be of an all-over coating, completely covering the substrate surface, or it may only cover specific parts of the substrate. Functional coatings may be applied to change the surface properties of the substrate, which include adhesion, wettability, corrosion resistance, or wear resistance. A major consideration for most of the coating processes is that the coating is to be applied at a controlled and small thickness, and a number of different processes are used to achieve this coating accurately.

### d) Thermal Spraying Process

The Thermal spraying techniques that are used for high temperature coating processes in which melted (or heated) materials are sprayed onto the surface. The "feedstock" also known as (coating precursor) is heated by an electrical (plasma or arc) or chemical means (combustion flame). Thermal spraying can provide thick and rigid coatings (approx. the thickness ranges from 20 microns to several millimeters, depending on the process and feedstock), over a large area at high deposition rate, as compared to the other coating processes such as electroplating, chemical vapour deposition, physical vapour deposition etc..

**Fig 1.(a) Thermal Spraying Technique**

**Fig 1.(b) Thermal Spraying Technique**

Although properties of coating materials are different in thickness and in plane directions, the materials behave linearly in each direction. The Coating quality is usually assessed by measuring its surface porosity, oxide content, macro and micro-hardness, bond strength and surface roughness. Generally, the quality of coating will increase with increasing particle velocities.

**e) The Types of Thermal Spraying Methods**

- Plasma spraying
- Detonation spraying
- Wire arc spraying
- Flame spraying
- High velocity oxy-fuel coating spraying (HVOF)
- High velocity air fuel (HVAF)
- Warm spraying
- Cold spraying

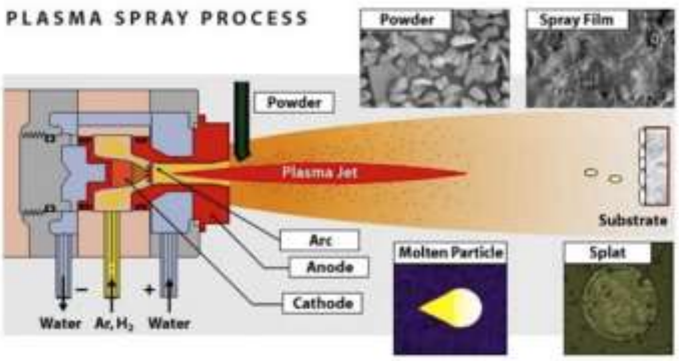


**Fig 2. Plasma Arc Welding**

**F) Thermal Spray System Consists Of**

- Spray torch (or spray gun) – the core device performing the melting and acceleration of the particles to be deposited.
- Feeder – for supplying the powder, wire or liquid to the torch through tubes.
- Media supply – gases or liquids for the generation of the flame or plasma jet, gases for carrying the powder, etc.
- Robot – for manipulating the torch or the substrates to be coated.
- Power supply – often standalone for the torch.

- Control console(s) – either integrated or individual for all of the above

The detonation gun which consists of a long water-cooled barrel with inlet valve used for gases and powder. The Oxygen and the fuel (acetylene most common) are fed into the barrel along with a charge of powder. An electric spark is used to ignite the gas mixture and the resulting detonation heats and accelerates the powder to supersonic velocity through the barrel. A pulse of nitrogen gas is used to purge the barrel after each detonation. This process is repeated many times in a second. The high kinetic energy of the hot and molten powder particles on impact with the substrate results in a buildup of a very dense and strong coating.

## 4. Methodology

### a) Piston Material

The numeric modelling of A390 Cast alloy diesel engine piston has done in Ansys workbench. The engine is rated at 3.7 kW at 1500 rev/min. The geometric compression ratio is 16.5:1. A water cooled four stroke single cylinder constant speed Diesel engine is used with bore diameter 80mm and stroke length 110mm. Ansys provide accurate results of analysis by dividing geometry into smaller elements.

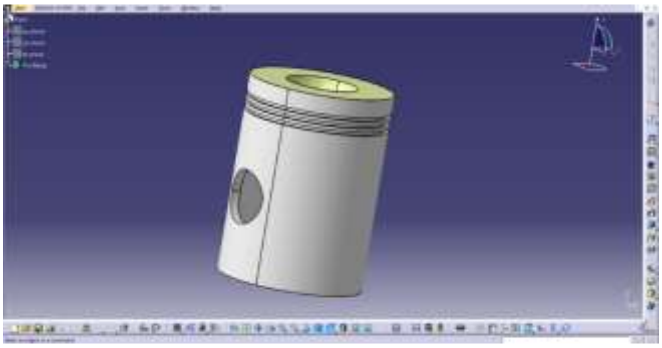


**Fig 3. Piston Model Drawn on CATIA V5 Software.**

### b) Ceramic Coating Materials

- **Single-layer coating**
  - Nickel Chromium (NiCr)
- **Multi-layer coating**
  - Aluminium Oxide + Silicon Dioxide ($Al_2O_3 + SiO_2$)
  - Chromium Carbide + Titanate ($Cr_3C_2 + TiO_3$)
  - Aluminium Oxide + Titanate ($Al_2O3 + TiO_3$)

### c) Properties Considered While Selecting the Ceramic Material

- High melting point
- No phase transformation between room temperature and operating temperature,
- Low thermal conductivity
- Chemical inertness
- Thermal expansion match with the metallic substrate
- Good adherence to the metallic substrate

## 5. Finite Element Analysis

Finite Element Analysis (FEA) was developed in 1943 by a scientist R. Courant, who used the Ritz method of numerical analysis and minimization of variational calculus to obtain approximate solutions for systems of vibration. Shortly after, an article published in 1956 by MJ Turner, RW Clough, HC Martin, and LJ Topp established a broader definition of numerical analysis. The paper centered on the "stiffness and deformation of complex structures".

FEA consists of a computer model of a material structure or design that is stressed under a load and analyzed for specific results. It is used in the design of new products, and refinement of the existing product. A company is able to verify a proposed design and will be able to perform the specification of the client before fabrication or construction. Modifying an existing product or structure is used to qualify the product or structure of a new condition of service. In the case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.

### *5.1. Calculation of Total Pressure Acting On the Piston*

The total pressure acting on the piston is calculated by subtracting the inertial loads from the gas pressure loads. So for the 80 mm diameter IC engine piston the gas force is taken as 10600 N.

Total Force acting on the Piston:

F = Gas Force – Inertia Force

= 10600 – 461.64

F = 10138.36 N

Total Pressure acting on the Piston:

P = The Total Force acting on the Piston / Piston Area

= 10138.36 / (π *802)

= 0.5MPa

### *5.2. Meshing*

FEM uses Lagrangian or Eulerian meshing criteria. The mesh of Lagrange is reformulated in almost each time step, in order to handle the deformation of the material. If a crash simulation, for any reason, a new simulation can start where the other stopped. A finer mesh gives a finer granularity. If the number of elements increases, also increases the time.

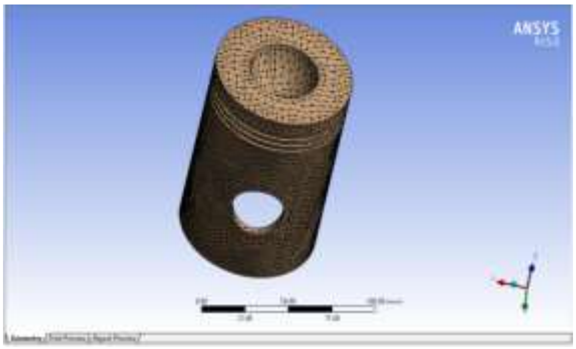


**Fig 4. Mesh without ceramic coating**

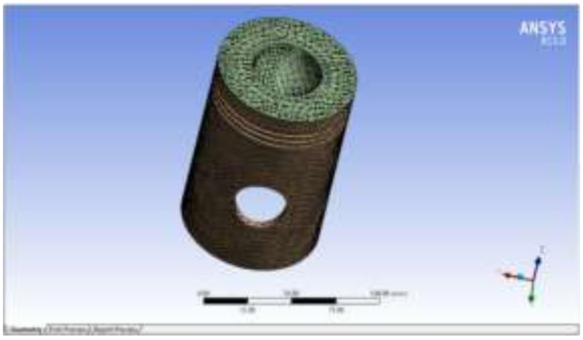


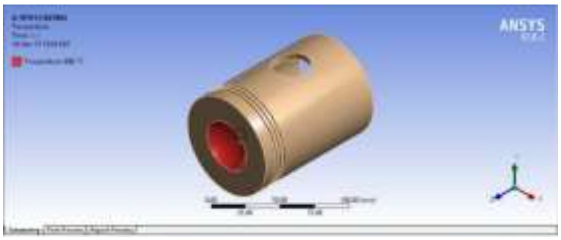
**Fig 5. Mesh with ceramic coating**

### *5.3. Steady State Thermal Analysis*

In this analysis properties of materials are considered to be constant with time, thus, steady-state thermal analysis is carried out in order to determine the temperature distribution of A390 cast iron pulley coated with different types of ceramic coating at various thicknesses. Steady state thermal analysis is useful to determine the highest temperature within the piston body which causes the piston performance. The heat transfer phenomena in the internal combustion engine was always have been a topic in research due to some complexity.

For the analysis convection is selected as a major mechanism of heat transfer. The heat transfer problem for the internal combustion engines are very complicated because of these following reasons.

Convection is taken as a major phenomenon of heat transfer in the piston. The Ambient Temperature is selected as 22°C and the convection heat transfer is8*e-004 W/mm². °C. And the temperature is 600°C.



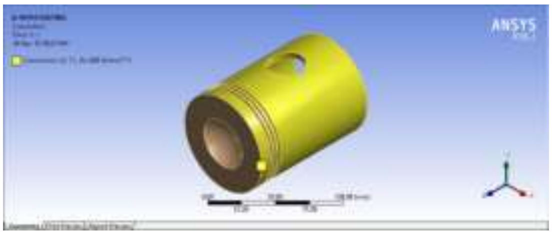


**Fig 6. Boundary Condition for temperature**

**Fig 7. Boundary Condition for Convection**

### *5.3.1 Steady State Thermal Analysis of Aluminium Oxide+Titanate ($Al_2O_3$ + $TiO_3$)*

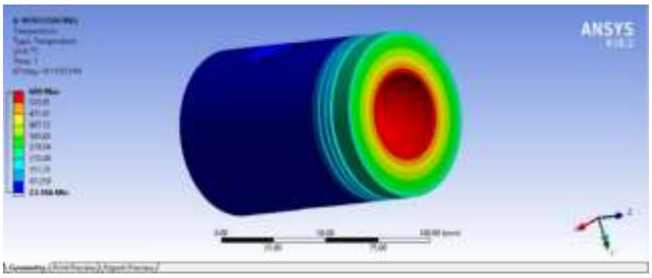


**Fig 8. Temperature distribution of Aluminium Oxide+Titanate ($Al_2O_3$ + $TiO_3$)**

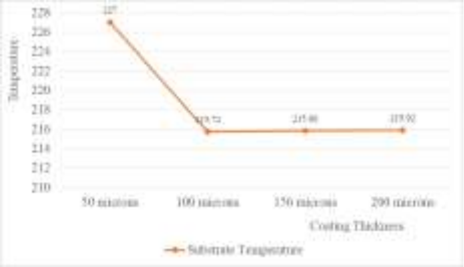


**Fig 9. Substrate temperature deviation for**

**Aluminium Oxide+Titanate ($Al_2O_3$ + $TiO_3$)**

In the steady state thermal analysis of Aluminium Oxide+Titanate ($Al_2O_3$ + $TiO_3$), the substrate temperature obtained for thicknesses 50, 100, 150, 200 Microns are given below. From steady state thermal analysis the temperature acting on the piston and the total heat flux on the piston are analyzed.

### *5.3.2. Steady State Thermal Analysis of Chromium Carbide + Titanate ($Cr_3C_2$ + $TiO_3$)*

In the steady state thermal analysis of Chromium Carbide + Titanate ($Cr_3C_2$ + $TiO_3$) the substrate temperature obtained for thicknesses 50, 100, 150, 200 Microns are given below. From steady state thermal analysis the temperature acting on the piston and the total heat flux on the piston are analyzed. And the substrate temperature at every thickness is obtained from the Ansys Software by applying the boundary conditions.

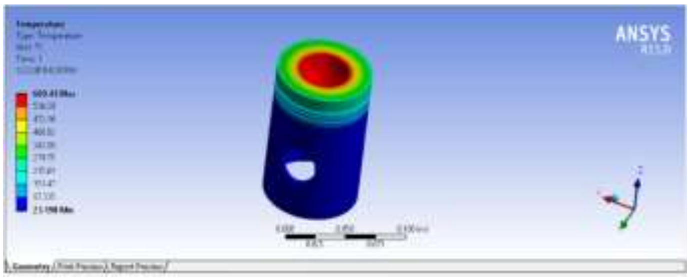


**Fig 10. Temperature distribution of**

**Chromium Carbide + Titanate ($Cr_3C_2$ + $TiO_3$)**

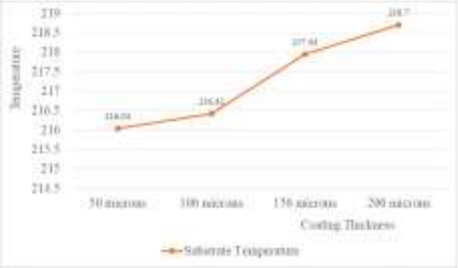


**Fig 11. Substrate temperature deviation for**

**Chromium Carbide + Titanate ($Cr_3C_2$ + $TiO_3$)**

### *5.3.3. Steady State Thermal Analysis of Aluminium Oxide+Silicon Dioxide ($Al_2O_3$ + $SiO_2$)*

In the steady state thermal analysis of Aluminium Oxide+Silicon Dioxide ($Al_2O_3$ + $SiO_2$) the substrate temperature obtained for thicknesses 50, 100, 150, 200 Microns are given below. From steady state thermal analysis the temperature acting on the piston and the total heat flux on the piston are analyzed. And the substrate temperature at every thickness is obtained from the Ansys Software by applying the boundary conditions.

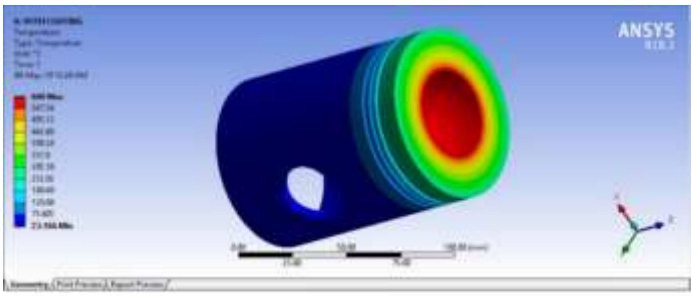


**Fig 12. Temperature distribution of**

**Aluminium Oxide+Silicon Dioxide ($Al_2O_3$ + $SiO_2$)**

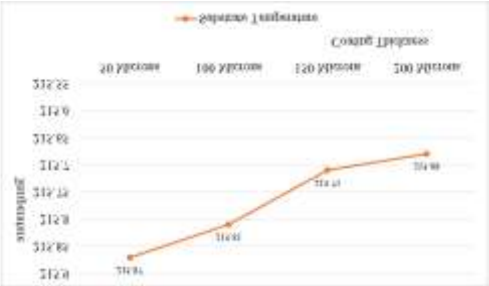


**Fig 13. Substrate temperature deviation for**

**Aluminium Oxide+Silicon Dioxide ($Al_2O_3$ + $SiO_2$)**

### *5.3.4 Steady State Thermal Analysis Of Nickel Chromium (NiCr)*

In the steady state thermal analysis of Nickel Chromium (NiCr) the substrate temperature obtained for thicknesses 50, 100, 150, 200 Microns are given below. From steady state thermal analysis the temperature acting on the piston and the total heat flux on the piston are analyzed. And the substrate temperature at every thickness is obtained from the Ansys Software by applying the boundary conditions

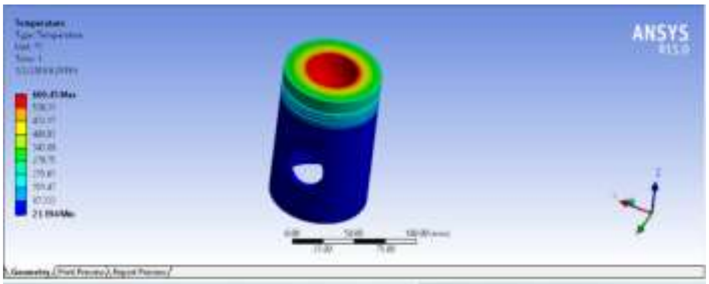


**Fig 14. Temperature distribution of Nickel Chromium (NiCr)**

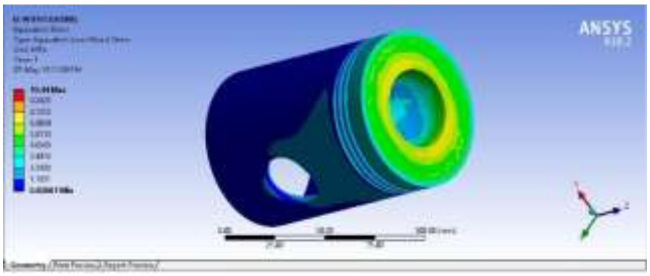
**Fig 15. Substrate temperature deviation for Nickel Chromium (NiCr)**

### *5.4. Static Structural Analysis*

When diesel engine is subjected to severe thermal loading, thermal stresses occur at the interfaces between layers, and the coating can be damaged. Depending on the nature of the crack, any point where maximum thermal stress occurs has the greatest potential in terms of formation of crack nucleation. One of the ceramic characteristics is brittleness, so small imperfections can easily spread into large cracks and the coating may delaminate from the bond coat. Therefore, it is important to determine the interfacial thermal stress distribution so as to keep the stresses within acceptable levels.

### *5.4.1 Static Structural Analysis of Aluminium Oxide+Titanate ($Al_2O_3$ + $TiO_3$)*

In the static structural analysis of Aluminium Oxide+Titanate ($Al_2O_3$ + $TiO_3$) the equivalent stress obtained for thicknesses 50, 100, 150, 200 Microns are given below. From static structural analysis the stress acting on the piston and the total deformation on the piston are analyzed. And the von mises stress at every thickness is obtained from the Ansys Software by applying the boundary conditions.



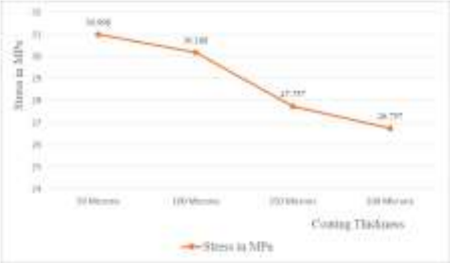


**Fig 16. Equivalent Stress distribution of Aluminium Oxide+Titanate ($Al_2O_3$ + $TiO_3$)**

**Fig 17. Stress distribution of Aluminium Oxide+Titanate ($Al_2O_3$ + $TiO_3$)**

### *5.4.2. Static Structural Analysis of Chromium Carbide + Titanate ($Cr_3C_2$ + $TiO_3$)*

In the static structural analysis of Chromium Carbide + Titanate ($Cr_3C_2$ + $TiO_3$) the equivalent stress obtained for thicknesses 50, 100, 150, 200 Microns are given below. From static structural analysis the stress acting on the piston and the total deformation on the piston are analyzed. And the von mises stress at every thickness is obtained from the Ansys Software by applying the boundary conditions.

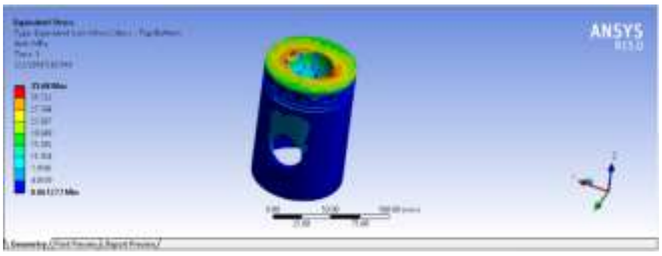


**Fig 18. Equivalent Stress distribution of**

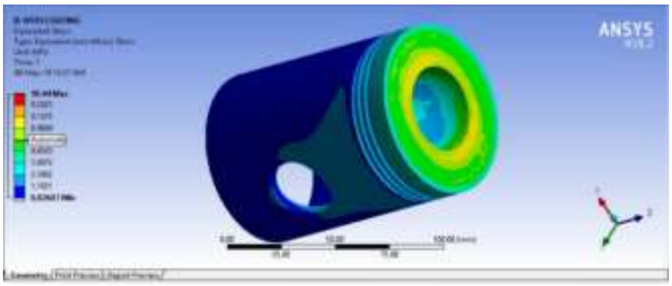
**Chromium Carbide + Titanate ($Cr_3C_2$ + $TiO_3$)**

**Fig 19. Stress distribution of**

**Chromium Carbide + Titanate ($Cr_3C_2$ + $TiO_3$)**

### *5.4.3. Static Structural Analysis of Aluminium Oxide+Silicon Dioxide ($Al_2O_3$ + $SiO_2$)*

In the static structural analysis of Aluminium Oxide+Silicon Dioxide ($Al_2O_3$ + $SiO_2$) the equivalent stress obtained for thicknesses 50, 100, 150, 200 Microns are given below. From static structural analysis the stress acting on the piston and the total deformation on the piston are analyzed. And the von mises stress at every thickness is obtained from the Ansys Software by applying the boundary conditions.



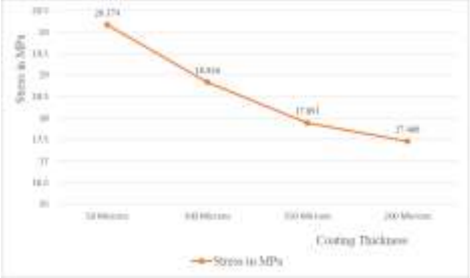


**Fig 20. Equivalent Stress distribution of**

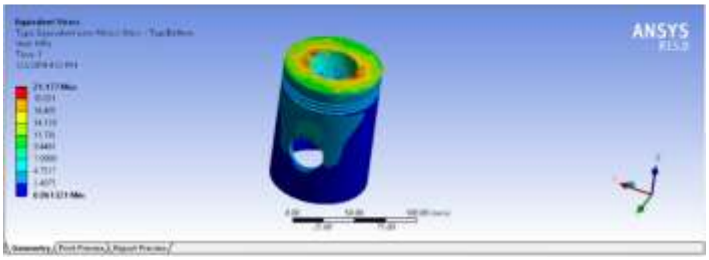
**Aluminium Oxide+Silicon Dioxide ($Al_2O_3$ + $SiO_2$)**

**Fig 21. Stress distribution of**

**Aluminium Oxide+Silicon Dioxide ($Al_2O_3$ + $SiO_2$)**

### *5.4.4. Static Structural Analysis of Nickel Chromium (Nicr)*

In the static structural analysis of Nickel Chromium (NiCr) the equivalent stress obtained for thicknesses 50, 100, 150, 200 Microns are given below. From static structural analysis the stress acting on the piston and the total deformation on the piston are analyzed. And the von mises stress at every thickness is obtained from the Ansys Software by applying the boundary conditions.



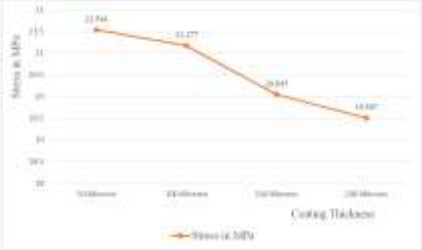


**Fig 22. Equivalent Stress distribution of Nickel Chromium (NiCr)**

**Fig 23. Stress distribution of Nickel Chromium (NiCr)**

## 6. Results and Discussion

The Thermal Stress Distributions for the coated and uncoated piston models shows that the thermal stress forming is maximum at the centre for uncoated model and at edges for the coated model. The Fig show that the thermal stress from centre along the length towards the edge for uncoated piston and sharply increases at the edges for the ceramic coatings. This rise in thermal stress at the ceramic coatings is due to the low thermal conductivity of ceramics.

The corresponding substrate temperature for the uncoated, Nickel Chromium (NiCr), Chromium Carbide + Titanate ($Cr_3C_2$ + $TiO_3$), Aluminium Oxide + Titanate ($Al_2O_3$ + $TiO_3$) and Aluminium Oxide+Silicon Dioxide ($Al_2O_3$+$SiO_2$) are shown in the table below.

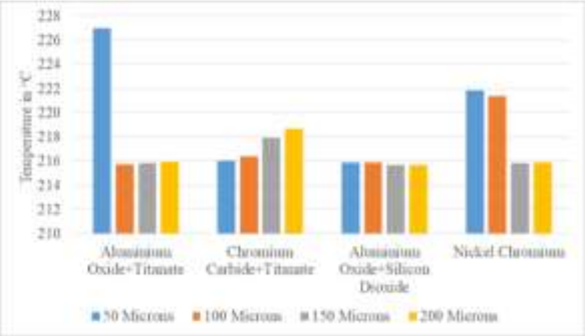


**Fig 24. Substrate temperature distribution of ceramic materials**

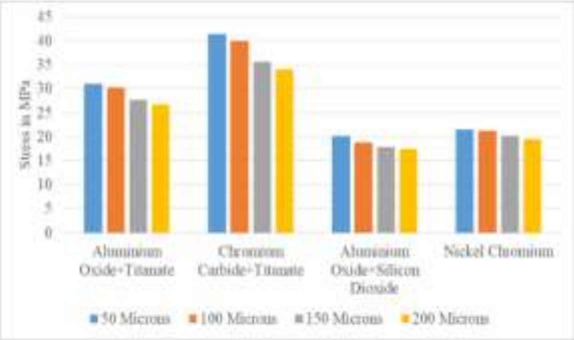


**Fig 25. Stress distribution in substrate region of ceramic materials**

**Fig 26. Comparison of temperature distribution of Ceramic coated piston with uncoated piston.**

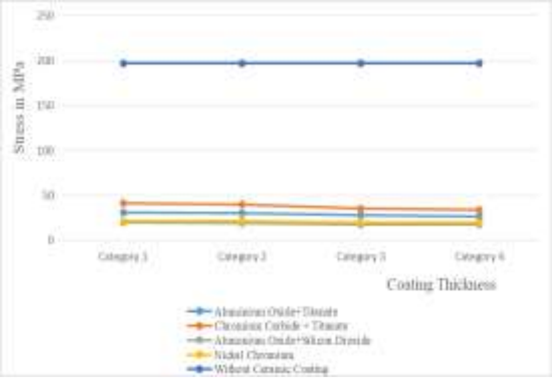


**Fig 27. Comparison of stress distribution of Ceramic coated piston with uncoated piston.**

For the uncoated piston, the surface temperature varies slightly which goes on decreasing from center to the edges. In case of coated pistons, the surface temperatures are same as uncoated piston up to the ceramic coated region. As it approaches the coated region, then the temperatures is increased abruptly and the variation is not linear. With the increase in coating thickness, the thermal conductivity of the ceramic materials will be low. Due to the lower conductivity of ceramics, the temperature at the ceramic coated surface increases.The design of IC Engine piston with Nano ceramic thermal barrier coatings which possess low thermal conductivity properties has great potential to improve the thermal load carrying capacity of the piston, reduce in-cylinder heat dissipation and improve the thermal efficiency of an IC engine. Comparative analyses were conducted between the ceramic thermal barrier coated piston and the conventional uncoated A390 Cast iron alloy piston. The optimum equivalent stress is also obtained for the multi-layered coating Aluminium Oxide+Silicon Dioxide ($Al_2O_3$+$SiO_2$) at a coating thickness of 200 Microns. The stress value obtained is 17.466 MPa. And when the obtained values are compared with the journal it is observed that rather than single layered ceramic coating, multi-layered coting provides more efficiency. And the multi-layer coating helps in resisting Hot Corrosion.

The percentage of reduction in substrate temperature is analyzed. And it is observed that Aluminium Oxide+Silicon Dioxide ($Al_2O_3$+$SiO_2$) at 200 Microns have 37.33% reduction in Substrate temperature. And the percentage reduction in substrate temperature obtained for thicknesses 50 Microns, 100 Microns and 150 Microns are 37.27%, 37.29% and 37.32% respectively. For Aluminium Oxide + Titanate ($Al_2O_3$ + $TiO_3$) the percentage reduction in substrate temperature obtained for thicknesses 50 Microns, 100 Microns, 150 Microns and 200 Microns are 34.04%, 37.32%, 37.28% and 37.26% respectively. For Chromium Carbide + Titanate ($Cr_3C_2$ + $TiO_3$) the percentage reduction in substrate temperature obtained for thicknesses 50 Microns, 100 Microns, 150 Microns and 200 Microns are 37.23%, 37.12%, 36.67% and 36.45% respectively. For Nickel Chromium (NiCr) the percentage reduction in substrate temperature obtained for thicknesses 50 Microns, 100 Microns, 150 Microns and 200 Microns are 35.69%, 35.67%, 37.26% and 37.28% respectively. The results obtained when the percentage reduction in stress distribution are analyzed. For Aluminium Oxide + Silicon Dioxide ($Al_2O_3$ + $SiO_2$) the percentage reduction in stress distribution obtained for thicknesses 50 Microns, 100 Microns, 150 Microns and 200 Microns are 89.78%, 90.45%, 90.93% and 91.153% respectively. For Chromium Carbide + Titanate ($Cr_3C_2$ + $TiO_3$) the percentage reduction in stress distribution obtained for thicknesses 50 Microns, 100 Microns, 150 Microns and 200 Microns are 79.04%, 79.78%, 81.92% and 82.79% respectively. For Aluminium Oxide + Titanate ($Al_2O_3$ + $TiO_3$) ) the percentage reduction in stress distribution obtained for thicknesses 50 Microns, 100 Microns, 150 Microns and 200 Microns are 84.29%, 84.70%, 85.94% and 86.44% respectively. For Nickel Chromium (NiCr) the percentage reduction in stress distribution obtained for thicknesses 50 Microns, 100 Microns, 150 Microns and 200Microns are 89.08%, 89.27%, 89.84% and 90.11% respectively. From the analysis results, the maximum temperature value of the ceramic coated piston was obtained at the pistons top surface bowl lip. Therefore, this area must be coated oversensitivity. Structural behaviors of the conventional metal materials are varied negatively with temperature. By means of ceramic coating, strength and deformation of the materials are improved.

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