Effect of Thermal Barrier Coating on Piston to Improve Engine Efficacy

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Abstract— In today's world scenario, there is tremendous development in the field of automobile and every day, there is a new invention to do better out transport facility. Also company may concentrated on very important fact, service after sale it is consider spinal code in the field of automobile. Most of the company may spend their 50% of their income on research and development to make their vehicle better. This project work is based on bi-metallic piston used in automobile. There are lots of thermal barrier coated materials used in automobile application. In this case, piston is identified with two metals. It reduces the thermal stress in the material to overcome this serious problem. Here in this thesis we have designed two different model pistons using CAD software – CATIA and Thermal analysis is done using two different materials i.e., AL 7075 and Cast iron coated with different materials such as SiC, titanium and Nickel.

Keywords: Thermal Barrier Coating, CAD software – CATIA, Piston

I. Introduction

The main function of piston is to receive the impulse from tte expanding gas and transmit the energy to the crank shafi through connecting rod. At the same time, the piston must also disperse a large amount of heat from the combustion chamber to the cylinder wall The profile of the piston head depend upon the design of the combustion chamber. The thermal stresses depend upon the temperatures and the efficiency of the engine. Amount of side thrust on the cylinder wall is a function of the connecting rod and the gas pressure. Many factors including the balancing of weights on the crank etc. will influence the number and type of piston rings used int hepfetoa Along the development of automobile technology, the reliability, efficieiwy, durability, operating per&rmaiKe of automobile engines are wished to be carried to a higher level. It is well known that almost all these properties of an internal combustion engine are closely associated with their mechanical behaviors. Thus it is necessary to reveal these mechanical characteristics of an engine in order to improve its general property and quality and it is far more important in piston system. To meet these requirements, tot of research works have been made for engine pistons axe many great developments have been achieved. Inspire of all tiiese improvements, there are a large number of damaged pistons. Although damage mechanfems have different origins, thermal fatigue alike mechanical fatigue play a prominent role. Heat load is the major factor to cause heat crack of piston head and mechanical bad is a major cause to bring crack at piston pin seat due to stress concentration. For a better understanding of the damaging mechanism and to enhance the serve life and the reliability of pistons, a great deal of complex mechanical fatigue tests and the hot fatigue tests are carried out by the piston manufacturers. These involve high cost and time. Consequently, finite element analysis is used for stresses and temperatures determination. In this, finite element thermo-mechanical coupling analysis, fetigue analysis and modal analysis are performed on a model of piston. Based on the results fix)m the analysis, practical guidelines can be provided for engine design in order to reduce engine bock vibration, suppress noise, improve efficiency etc. There is a continuous terrain carried out to deep internal combusting engines of increased power capacity and performance. This has been made possible by improved engine design including increased compression ratio, engine speed and using better material for high performance. Due to these reasons, the role of the piston which is one of the fastest moving parts of the engine has become of vital importance. The piston speed may be 15 m/s or even more and at such high speeds, heavy reciprocating piston develops high inertia force, which is undesirable. Therefore, for high speed engines, weight of the piston is of primary importance bang with other design factor. Thus for the design of internal combustion engine piston, the following objects must be sought:

Fig. 1.1: A piston contained inside of a cylinder, used within a sectioned gasoline engine

A piston is a moving disk enclosed in a cylinder which is made gas-tight by piston rings. The disk moves inside the cylinder as a liquid or gas inside the cylinder expands and contracts. A piston aids in the transformation of heat energy into mechanical work and vice versa. Because of this, pistons are a key component of heat engines.[2] Pistons work by transferring the force output of an expanding gas in the cylinder to a crankshaft, which provides rotational momentum to a flywheel. Such a system is known as a reciprocating engine.

A piston must follow a cyclical process in order for it to continuously convert heat energy to work, and there are many ways to complete this cycle. For example:

By inputting heat to the gas inside the cylinder, the gas will expand increasing the volume in the cylinder and provide useful work.

By removing heat from the cylinder, the gas's pressure will decrease, allowing it to be compressed more easily.

By inputting work to the piston, the piston will compress back to its initial state, ready to perform the cycle once again.

This cycle can be visualized in Figure 1.2 below

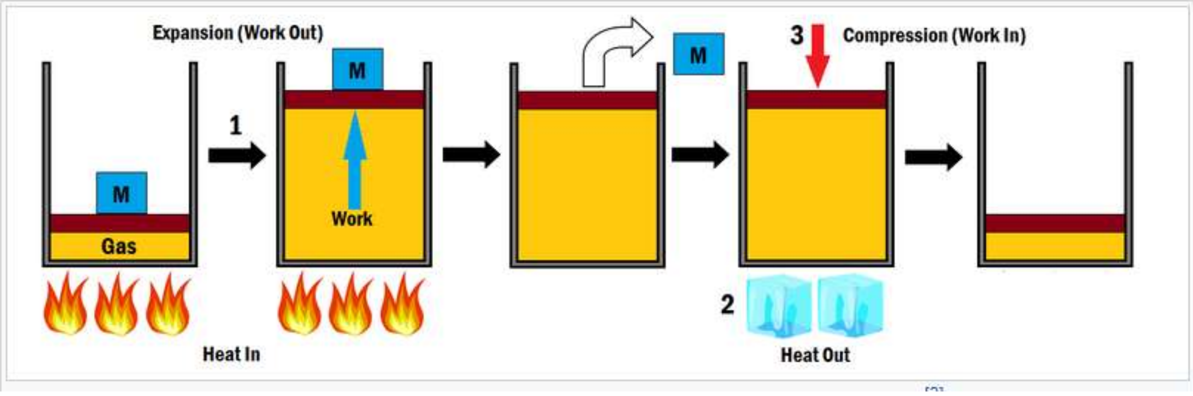


Fig. 1.2:

These steps can be done differently and the processes can become very complex, however this is a simple example of how a piston can be made to perform useful work through the input of heat. It is known that this heat cannot be transformed fully into work, otherwise the entropy of the system would decrease which is forbidden by the Second law of thermodynamics.

Materials for TBCs

Various TBC materials.

Sr. No.	TBC material	Sr. No.	TBC material
1	ZrO_2	1	Garnet ($Y_3Al_5O_{12}$)
2	3YSZ	2	Lanthanum aluminate ($LaMgAl_{11}O_{19}$)
3	8YSZ (plasma-sprayed)	3	$LaPO_4$
4	18YSZ	4	NiCoCrAlY (bond coat of TBC)
5	Al_2O_3 (TGO)	5	IN737 super alloy (substrate of TBC)
6	$Al_2O_3 + TiO_2$	6	AlSi
7	CeO_2	7	Mg-PSZ
8	$La_2Zr_2O_7$	8	Y-PSZ
9	$BaZrO_3$	9	$CaZrO_3$
10	TiO_2	10	$MgZrO_3$
11	Cordierite	11	Forsterite

TBC materials used in IC engines.

Sr. No.	TBC materials
1	3YSZ
2	Mullite
3	Al_2O_3
4	AlSi
5	NiCrAl
6	Mg-PSZ
7	Y-PSZ
8	$CaZrO_3$
9	$MgZrO_3$

A. *Thermal barrier coatings (TBCs)*

Thermal barrier coatings (TBCs) are advanced materials systems usually applied to metallic surfaces operating at elevated temperatures, such as gas turbine or aero-engine parts, as a form of exhaust heat management. These 100 μm to 2 mm thick coatings of thermally insulating materials serve to insulate components from large and prolonged heat loads and can sustain an appreciable temperature difference between the load-bearing alloys and the coating surface. In doing so, these coatings can allow for higher operating temperatures while limiting the thermal exposure of structural components, extending part life by reducing oxidation and thermal fatigue. In conjunction with active film cooling, TBCs permit working fluid temperatures higher than the melting point of the metal airfoil in some turbine applications. Due to increasing demand for more efficient engines running at higher temperatures with better durability/lifetime and thinner coatings to reduce parasitic mass for rotating/moving components, there is significant motivation to develop new and advanced TBCs. The material requirements of TBCs are similar to those of heat shields, although in the latter application emissivity tends to be of greater importance.

1) *Types of TBCs*

a) YSZ

YSZ is the most widely studied and used TBC because it provides excellent performance in applications such as diesel engines and gas turbines. Additionally, it was one of the few refractory oxides that could be deposited as thick films using the then-known technology of plasma spraying. As for properties, it has low thermal conductivity, high thermal expansion coefficient, and low thermal shock resistance. However, it has a fairly low operating limit of 1200°C due to phase instability, and can corrode due to its oxygen transparency.

b) Mullite

Mullite is a compound of alumina and silica, with the formula 3Al2O3-2SiO2. It has a low density, along with good mechanical properties, high thermal stability, low thermal conductivity, and is corrosion and oxidation resistant. However, it suffers from crystallization and volume contraction above 800°C, which leads to cracking and delamination. Therefore, this material is suitable as a zirconia alternative for applications such as diesel engines, where surface temperatures are relatively low and temperature variations across the coating may be large.

c) Alumina

Only α-phase Al2O3 is stable among aluminum oxides. With a high hardness and chemical inertness, but high thermal conductivity and low thermal expansion coefficient, alumina is often used as an addition to an existing TBC coating. By incorporating alumina in YSZ TBC, oxidation and corrosion resistance can be improved, as well as hardness and bond strength without significant change in the elastic modulus or toughness. One challenge with alumina is applying the coating through plasma spraying, which tends to create a variety of unstable phases, such as γ-alumina. When these phases eventually transform into the stable α-phase through thermal cycling, a significant volume change of ~15% (γ to α) follows, which can lead to microcrack formation in the coating.

d) CeO2 + YSZ

CeO2 (Ceria) has a higher thermal expansion coefficient and lower thermal conductivity than YSZ. Adding ceria into a YSZ coating can significantly improve the TBC performance, especially in thermal shock resistance. This is most likely due to less bond coat stress due to better insulation and a better net thermal expansion coefficient. Some negative effects of the addition of ceria include the decrease of hardness and accelerated rate of sintering of the coating (less porous).

e) Rare-earth zirconates

$La_2Zr_2O_7$, also referred to as LZ, is an example of a rare-earth zirconate that shows potential for use as a TBC. This material is phase stable up to its melting point and can largely tolerate vacancies on any of its sublattices. Along with the ability for site-substitution with other elements, this means that thermal properties can potentially be tailored. Although it has a very low thermal conductivity compared to YSZ, it also has a low thermal expansion coefficient and low toughness.

f) Rare earth oxides

Single and mixed phase materials consisting of rare earth oxides represent a promising low-cost approach towards TBCs. Coatings of rare earth oxides (e.g.: La2O3, Nb2O5, Pr2O3, CeO2 as main phases) have lower thermal conductivity and higher thermal expansion coefficients when compared to YSZ. The main challenge to overcome is the polymorphic nature of most rare earth oxides at elevated temperatures, as phase instability tends to negatively impact thermal shock resistance. Another advantage of rare earth oxides as TBCs is their tendency to exhibit intrinsic hydrophobicity,[9] which provides various advantages for systems that undergo intermittent use and may otherwise suffer from moisture adsorption or surface ice formation.

g) Metal-Glass Composites

A powder mixture of metal and normal glass can be plasma-sprayed in vacuum, with a suitable composition resulting in a TBC comparable to YSZ. Additionally, metal-glass composites have superior bond-coat adherence, higher thermal expansion coefficients, and no open porosity, which prevents oxidation of the bond-coat.

h) Piston and Piston Rings

A piston is a cylindrical engine component that slides back and forth in the cylinder bore by forces produced during the combustion process. The piston acts as a movable end of the combustion chamber. The stationary end of the combustion chamber is the cylinder head. Pistons are commonly made of a cast aluminum alloy for excellent and lightweight thermal conductivity. Thermal conductivity is the ability of a material to conduct and transfer heat. Aluminum expands when heated, and proper clearance must be provided to maintain free piston movement in the cylinder bore. Insufficient clearance can cause the piston to seize in the cylinder. Excessive clearance can cause a loss of compression and an increase in piston noise.

Piston features include the piston head, piston pin bore, piston pin, skirt, ring grooves, ring lands, and piston rings. The piston head is the top surface (closest to the cylinder head) of the piston which is subjected to tremendous forces and heat during normal engine operation.

A piston pin bore is a through hole in the side of the piston perpendicular to piston travel that receives the piston pin. A piston pin is a hollow shaft that connects the small end of the connecting rod to the piston. The skirt of a piston is the portion of the piston closest to the crankshaft that helps align the piston as it moves in the cylinder bore. Some skirts have profiles cut into them to reduce piston mass and to provide clearance for the rotating crankshaft counterweights.

A ring groove is a recessed area located around the perimeter of the piston that is used to retain a piston ring. Ring lands are the two parallel surfaces of the ring groove which function as the sealing surface for the piston ring. A piston ring is an expandable split ring used to provide a seal between the piston an the cylinder wall. Piston rings are commonly made from cast iron. Cast iron retains the integrity of its original shape under heat, load, and other dynamic forces. Piston rings seal the combustion chamber, conduct heat from the piston to the cylinder wall, and return oil to the crankcase. Piston ring size and configuration vary depending on engine design and cylinder material.

Piston rings commonly used on small engines include the compression ring, wiper ring, and oil ring. A compression ring is the piston ring located in the ring groove closest to the piston head. The compression ring seals the combustion chamber from any leakage during the combustion process. When the air-fuel mixture is ignited, pressure from combustion gases is applied to the piston head, forcing the piston toward the crankshaft. The pressurized gases travel through the gap between the cylinder wall and the piston and into the piston ring groove. Combustion gas pressure forces the piston ring against the cylinder wall to form a seal. Pressure applied to the piston ring is approximately proportional to the combustion gas pressure.

A wiper ring is the piston ring with a tapered face located in the ring groove between the compression ring and the oil ring. The wiper ring is used to further seal the combustion chamber and to wipe the cylinder wall clean of excess oil. Combustion gases that pass by the compression ring are stopped by the wiper ring.

An oil ring is the piston ring located in the ring groove closest to the crankcase. The oil ring is used to wipe excess oil from the cylinder wall during piston movement. Excess oil is returned through ring openings to the oil reservoir in the engine block. Two-stroke cycle engines do not require oil rings because lubrication is supplied by mixing oil in the gasoline, and an oil reservoir is not required.

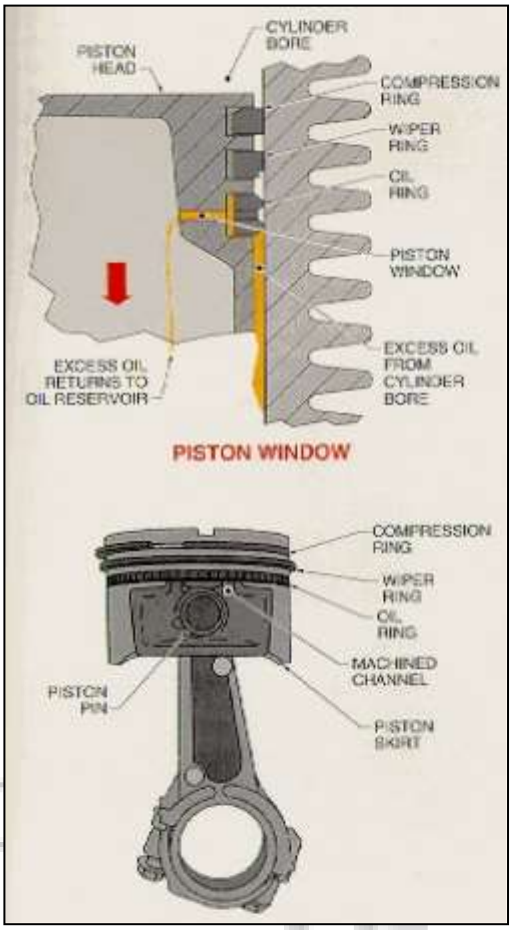


Fig. 1.3: Piston Window

Piston rings seal the combustion chamber, transferring heat to the cylinder wall and controlling oil consumption. A piston ring seals the combustion chamber through inherent and applied pressure. Inherent pressure is the internal spring force that expands a piston ring based on the design and properties of the material used. Inherent pressure requires a significant force needed to compress a piston ring to a smaller diameter. Inherent pressure is determined by the uncompressed or free piston ring gap. Free piston ring gap is the distance between the two ends of a piston ring in an uncompressed state. Typically, the greater the free piston ring gap, the more force the piston ring applies when compressed in the cylinder bore.

A piston ring must provide a predictable and positive radial fit between the cylinder wall and the running surface of the piston ring for an efficient seal. The radial fit is achieved by the inherent pressure of the piston ring. The piston ring must also maintain a seal on the piston ring lands.

In addition to inherent pressure, a piston ring seals the combustion chamber through applied pressure. Applied pressure is pressure applied from combustion gases to the piston ring, causing it to expand. Some piston rings have a chamfered edge opposite the running surface. This chamfered edge causes the piston ring to twist when not affected by combustion gas pressures.

Another piston ring design consideration is cylinder wall contact pressure. This pressure is usually dependent on the elasticity of the piston ring material, free piston ring gap, and exposure to combustion gases. All piston rings used by Briggs & Stratton engines are made of cast iron. Cast iron easily conforms to the cylinder wall. In addition, cast iron is easily coated with other materials to enhance its durability. Care must be exercised when handling piston rings, as cast iron is easily distorted. Piston rings commonly used on small engines include the compression ring, wiper ring, and oil ring.

2) Compression Ring

The compression ring is the top or closest ring to combustion gases and is exposed to the greatest amount of chemical corrosion and the highest operating temperature. The compression ring transfers 70% of the combustion chamber heat from the piston to the cylinder wall. Most Briggs & Stratton engines use either taper-faced or barrel-faced compression rings. A taper faced compression ring is a piston ring that has approximately a 1° taper angle on the running surface. This taper provides a mild wiping action to prevent any excess oil from reaching the combustion chamber.A barrel faced compression ring is a piston ring that has a curved running surface to provide consistent lubrication of the piston ring and cylinder wall. This also provides a wedge effect to optimize oil distribution throughout the full stroke of the piston. In addition, the curved running surface reduced the possibility of an oil film breakdown due to excess pressure at the ring edge or excessive piston tilt during operation.

3) Wiper Ring

The wiper ring, sometimes called the scraper ring, Napier ring, or back-up compression ring, is the next ring away from the cylinder head on the piston. The wiper ring provides a consistent thickness of oil film to lubricate the running surface of the compression ring. Most wiper rings in Briggs & Stratton engines have a taper angle face. The tapered angle is positioned toward the oil reservoir and provides a wiping action as the piston moves toward the crankshaft.

The taper angle provides contact that routes excess oil on the cylinder wall to the oil ring for return to the oil reservoir. A wiper ring incorrectly installed with the tapered angle closest to the compression ring results in excessive oil consumption. This is caused by the wiper ring wiping excess oil toward the combustion chamber.

4) Oil Ring

An oil ring includes two thin rails or running surfaces. Holes or slots cut into the radial center of the ring allow the flow of excess oil back to the oil reservoir. Oil rings are commonly one piece, incorporating all of these features. Some on-piece oil rings utilize a spring expander to apply additional radial pressure to the piston ring. This increases the unit (measured amount of force and running surface size) pressure applied at the cylinder wall.

The oil ring has the highest inherent pressure of the three rings on the piston. Some Briggs & Stratton engines use a tree-piece oil ring consisting of two rails and an expander. The oil rings are located on each side of the expander. The expander usually contains multiple slots or windows to return oil to the piston ring groove. The oil ring uses inherent piston ring pressure, expander pressure, and the high unit pressure provided by the small running surface of the thin rails.

The piston acts as the movable end of the combustion chamber and must withstand pressure fluctuations, thermal stress, and mechanical load. Piston material and design contribute to the overall durability and performance of an engine. Most pistons are made from die- or gravity-cast aluminum alloy. Cast aluminum alloy is lightweight and has good structural integrity and low manufacturing costs. The light weight of aluminum reduces the overall mass and force necessary to initiate and maintain acceleration of the piston. This allows the piston to utilize more of the force produced by combustion to power the application. Piston designs are based on benefits and compromises for optimum overall engine performance.

II. MODELING AND ANALYSIS

Computer Aided Design-CAD is defined the use of information technology (IT) in the Design process. A CAD system consists of IT hardware (H/W), specialized software (S/W) (depending on the area of application) and peripherals, which in certain applications are quite specialized. The core of a CAD system is the S/W, which makes use of graphics for product representation; databases for storing the product model and drives the peripherals for product presentation it does not change the nature of the design process but as the name states it aids the product designer. The role of the CAD is in aiding him/her by providing:

Accurately generated and easily modifiable graphical representation of the product. The user can nearly view the actual product on screen, make any modifications to it, and present his/her ideas on screen without any prototype, especially during the early stages of the design process.

Perform complex design analysis in short time. Implementing Finite Elements Analysis methods, the user can perform: Static, Dynamic and Natural Frequency analysis, Heat transfer analysis, Plastic analysis, Fluid flow analysis, Motion analysis, Tolerance analysis, Design optimization.

Record and recall information with consistency and speed. The use of Product Data Management (PDM) systems can store the whole design and processing history of a certain product, for future reuse and upgrade.

CATIA V5 is a computer aided design application that will help you to design any product you can imagine. In this course, Introduction to CATIA V5, you'll be introduced to CATIA V5 and learn how to use its workbench features in practice. First, you'll begin by learning the inner workings of the CATIA V5 Part Design workbench, and how to create a bike pedal. Next, you'll delve into a journey with the assembly workbench and install the pedal you made on the bike. Finally, you'll discover how to create a drawing of the pedal and multiple drawing views, all while adding some dimensions in the Drafting workbench. By the end of this course, you'll have the necessary skills and knowledge to create your own shapes, and confidently utilize part design and workbenches in CATIA V5. Software required: CATIA V5.

A. *Sketcher Module*

The Sketcher workbench is a set of tools that helps you create and constrain 2D geometries. Features (pads, pockets, shafts, etc...) may then be created solids or modifications to solids using these 2D profiles. You can access the Sketcher workbench in many ways. Two simple ways are by using the top pull down menu (Start – Mechanical Design – Sketcher), or by selecting the Sketcher icon. When you enter the sketcher, CATIA requires that you choose a plane to sketch on. You can choose this plane either before or after you select the Sketcher icon. To exit the sketcher, select the Exit Workbench icon.

1) *Part Design Module*

Part design environment is used to create 3D models from the basic 2D sketches created in sketcher environment.

2) *Assembly Module*

Assembly environment is used to provide mating to two or more part models to from complete assembly.

3) *Drafting Module*

Drafting is a process of generating 2D machine drawing for the 3D part models to send it to the manufacturers.

CATIA drafting is of two types

1) Interactive Drafting
2) Generative Drafting

B. *3D Model*

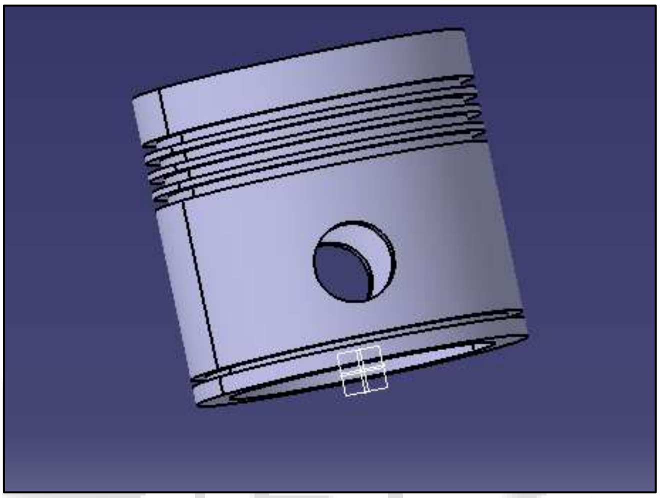


Fig. 2.1: 3D model

1) *Finite Element Analysis*

FEA is the basis of modern software simulation software, with the results usually shown on a computer-generated colour scale.

While some theories state that FEA has its roots in the 16th century work of Euler, the earliest mathematical papers directly detailing the technique date back to Schellbach's work of 1851. FEA was developed further by engineers from different industries around the world in order to solve a large number of structural mechanics problems, primarily in civil engineering and aerospace. The first development of FEA for real world applications began in the mid-1950s and was further developed over the next few decades.

2) *Static Analysis*

Used to determine displacements, stresses, etc. under static loading conditions. ANSYS can compute both linear and nonlinear static analyses. Nonlinearities can include plasticity, stress stiffening, large deflection, large strain, hyper elasticity, contact surfaces, and creep.

Thermomechanical analysis (TMA) is a technique used in thermal analysis, a branch of materials science which studies the properties of materials as they change with temperature.

Thermomechanical analysis is a sub discipline of the thermomechanometry (TM) technique.

a) Related techniques and terminology

Thermomechanometry is the measurement of a change of a dimension or a mechanical property of the sample while it is subjected to a temperature regime. An associated thermoanalytical method is thermomechanical analysis. A special related technique is thermodilatometry (TD), the measurement of a change of a dimension of the sample with a negligible force acting on the sample while it is subjected to a temperature regime. The associated thermoanalytical method is thermodilatometric analysis (TDA).

TDA is often referred to as zero force TMA. The temperature regime may be heating, cooling at a rate of temperature change that can include stepwise temperature changes, linear rate of change, temperature modulation with a set frequency and amplitude, free (uncontrolled) heating or cooling, or maintaining a constant increase in temperature. The sequence of temperatures with respect to time may be predetermined (temperature programmed) or sample controlled (controlled by a feedback signal from the sample response).

Thermomechanometry includes several variations according to the force and the way the force is applied.Static force TM (sf-TM) is when the applied force is constant; previously called TMA with TD as the special case of zero force.Dynamic force TM (df-TM) is when the force is changed as for the case of a typical stress–strain analysis; previously called TMA with the term dynamic meaning any alteration of the variable with time, and not to be confused with dynamic mechanical analysis (DMA).Modulated force TM (mf-TM) is when the force is changed with a frequency and amplitude; previously called DMA. The term modulated is a special variant of dynamic, used to be consistent with modulated temperature differential scanning calorimetry (mt-DSC) and other situations when a variable is imposed in a cyclic manner.

III. MATERIAL PROPERTIES

AL-7075:
Thermal conductivity: 151w/mk
COMPOSITION

A. *EXISTING MATERIAL*

Material properties of cast iron

Properties of Outline Row 3: Gray Cast Iron

	A	B	C
1	Property	Value	Unit
2	Density	7200	kg m^-3
3	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
7	Derive from	Young's ...	
8	Young's Modulus	1.1E+11	Pa
9	Poisson's Ratio	0.28	

Total deformation

Aluminum 94.7%
Copper 4.9%
Magnesium 1.8%
Zinc 0.25%

IV. STATIC ANALYSIS OF PISTON

1) *Imported model*

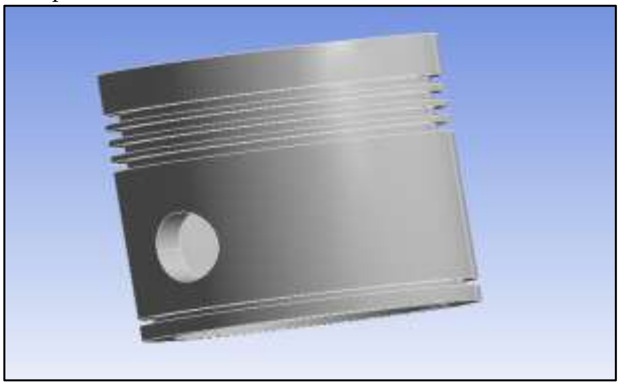
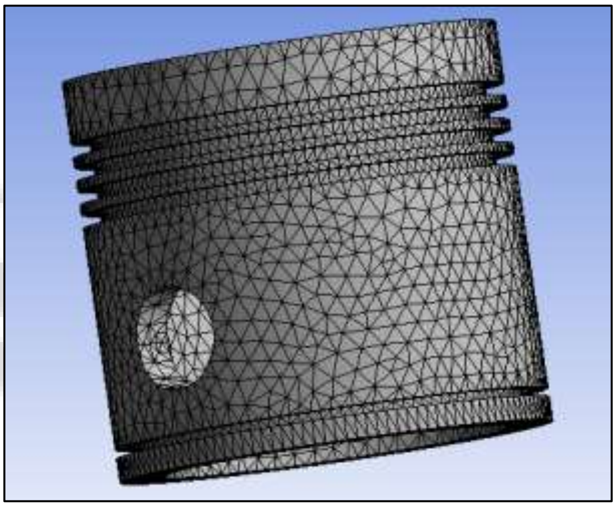
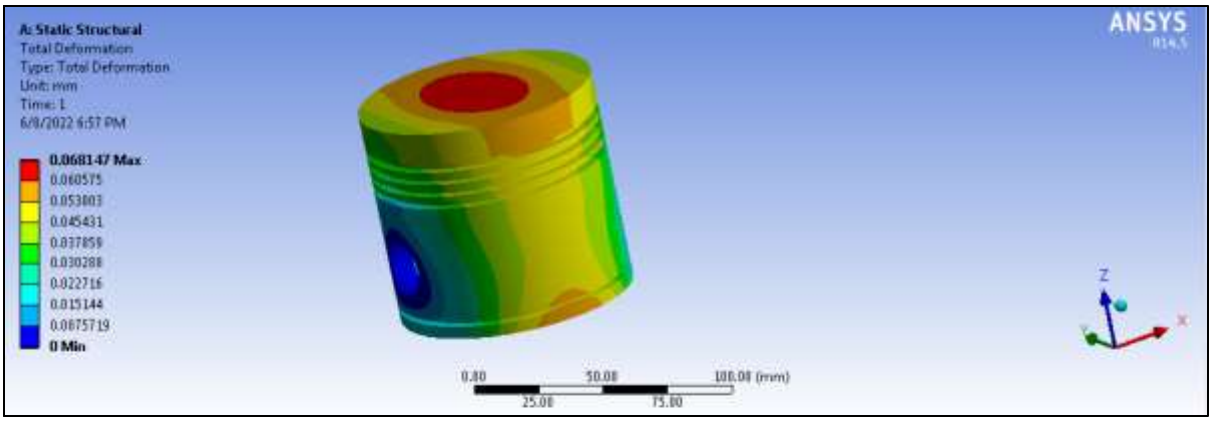


Fig. 3.1: Imported Model

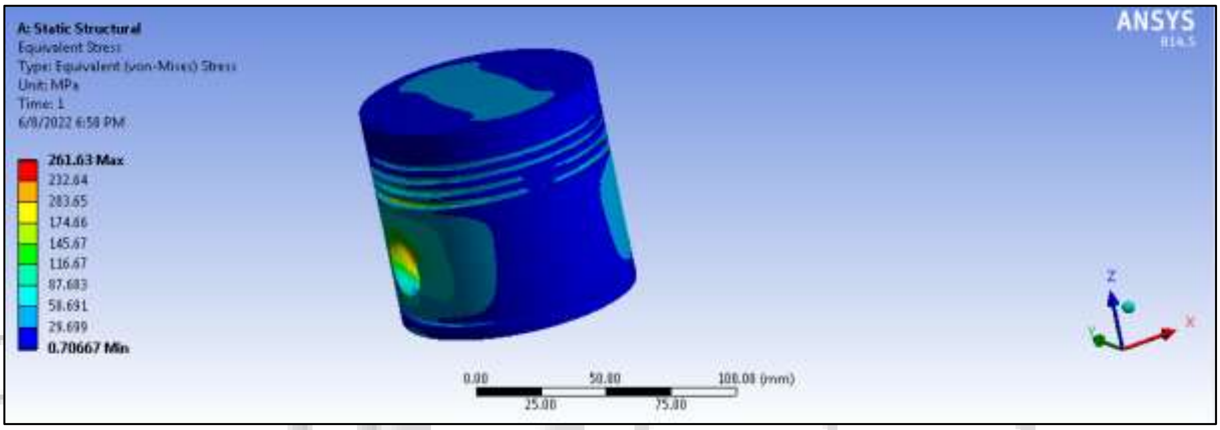
2) *Meshed model*



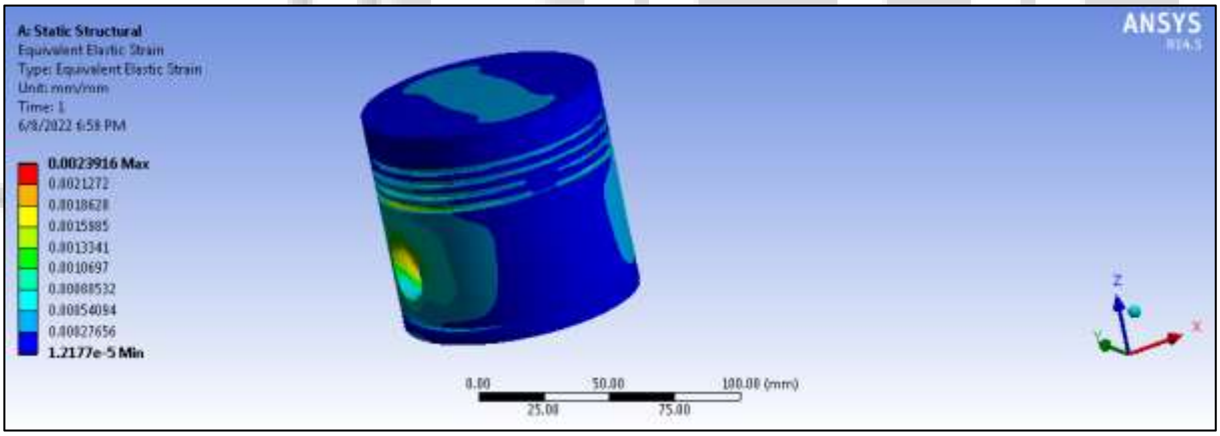
Meshed Model



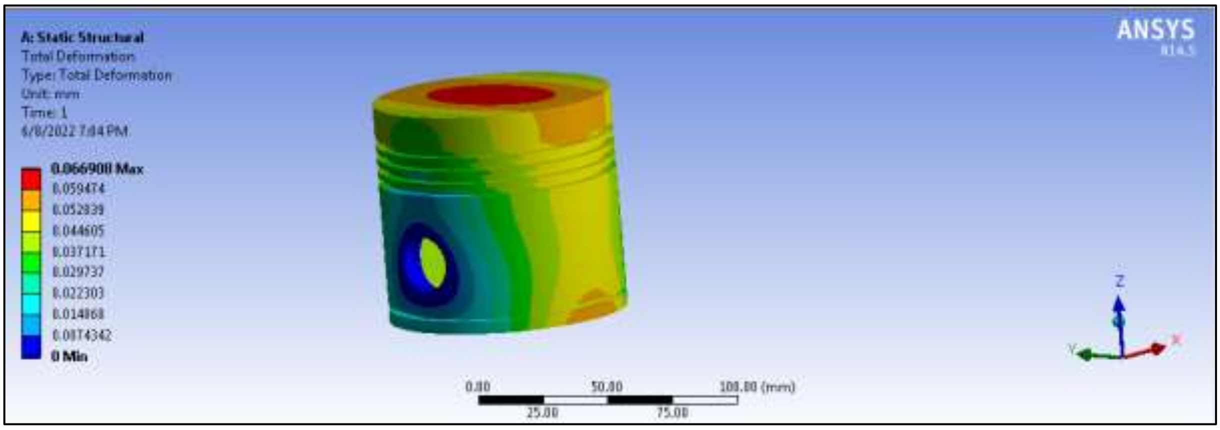
Stress



Strain



Material-cast-iron with SiC coated
Total deformation



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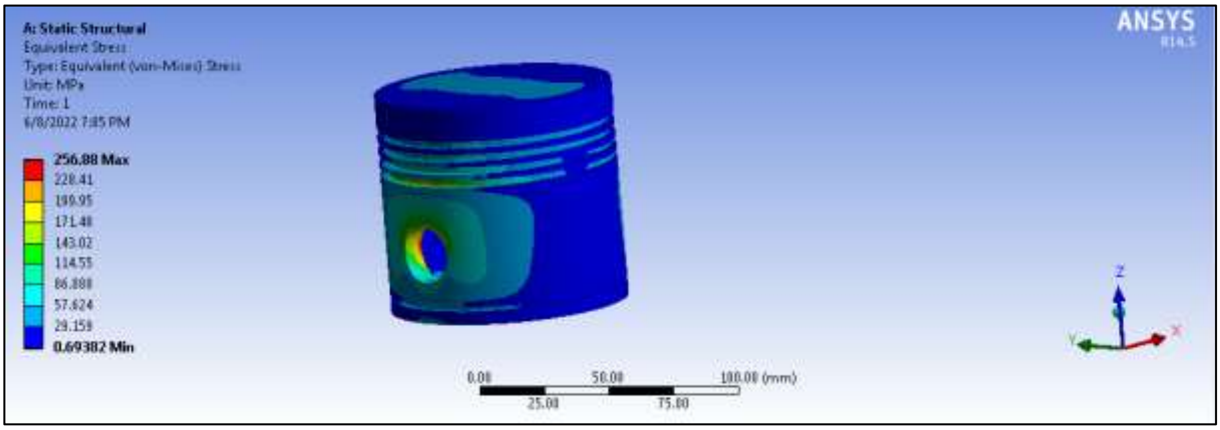
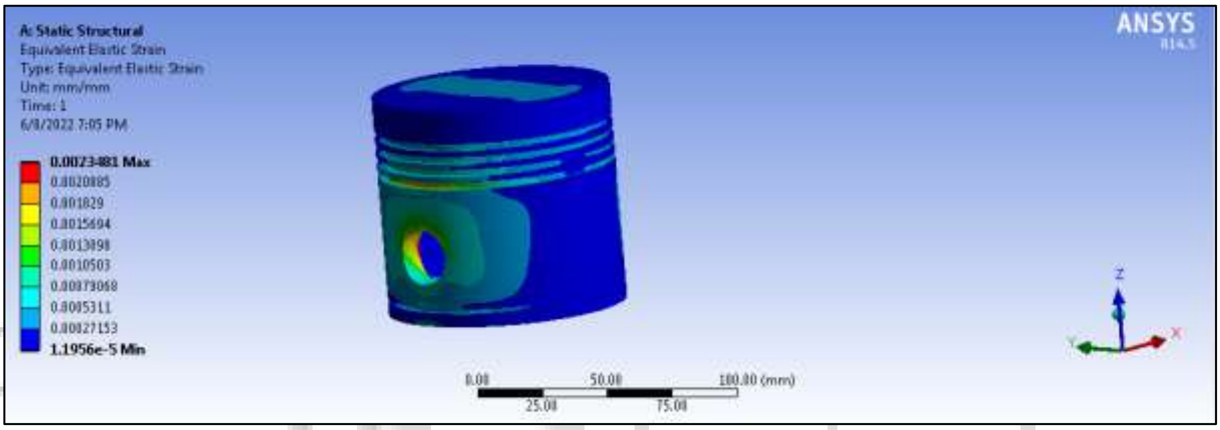
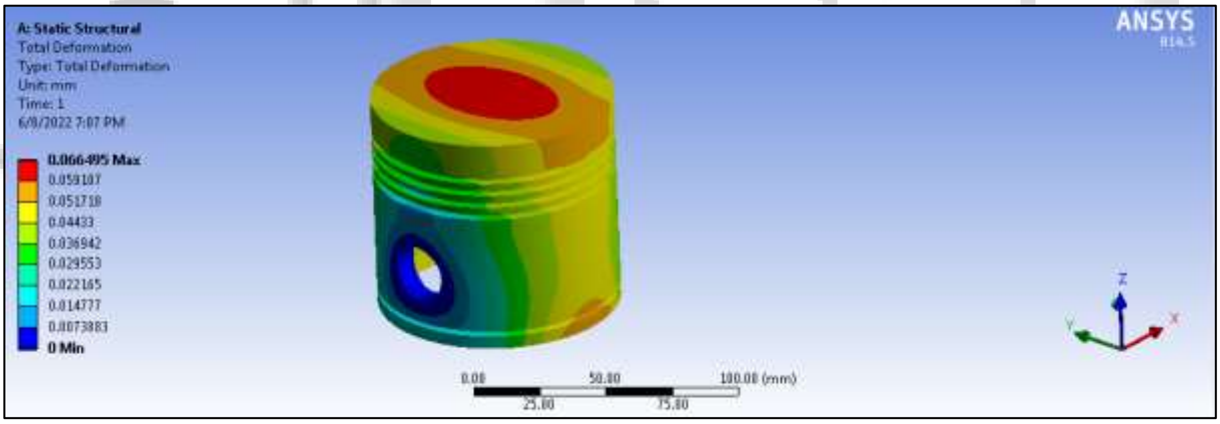


Strain



Material-cast-iron with Titanium coated

Total deformation



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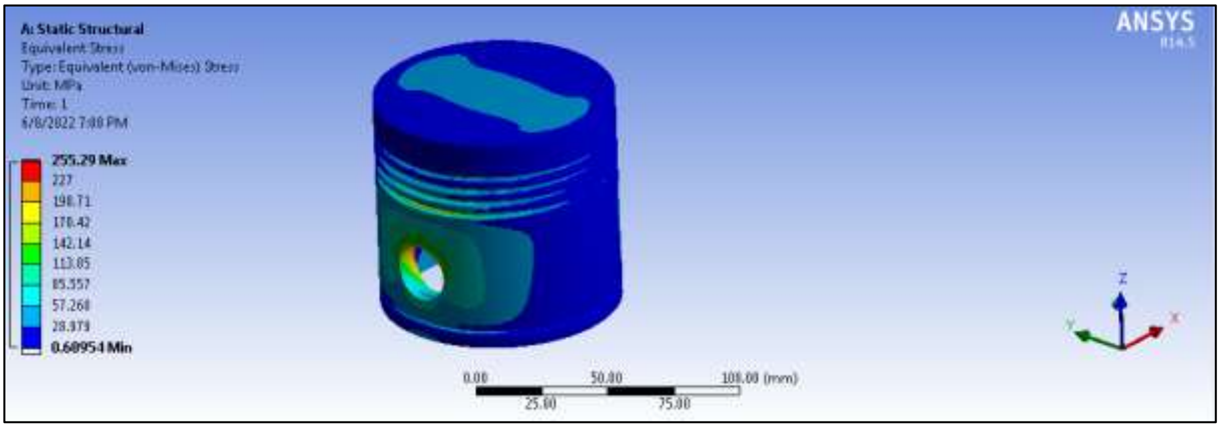

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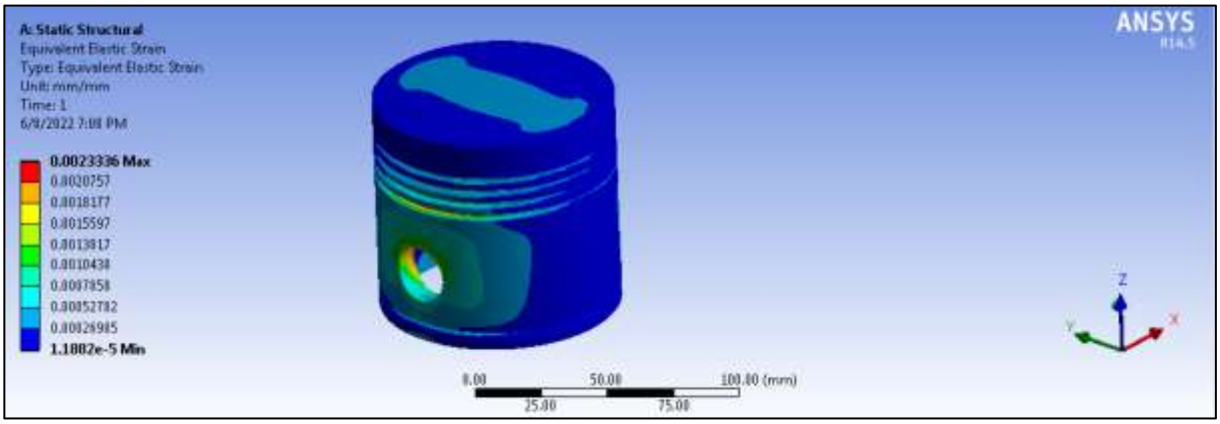
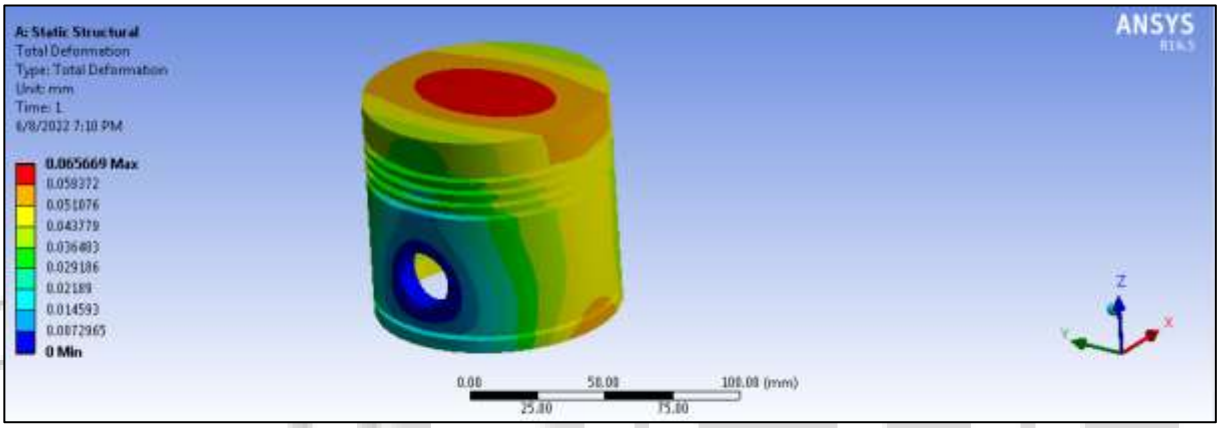


Material-cast-iron with Nickel chromium coated

Total deformation



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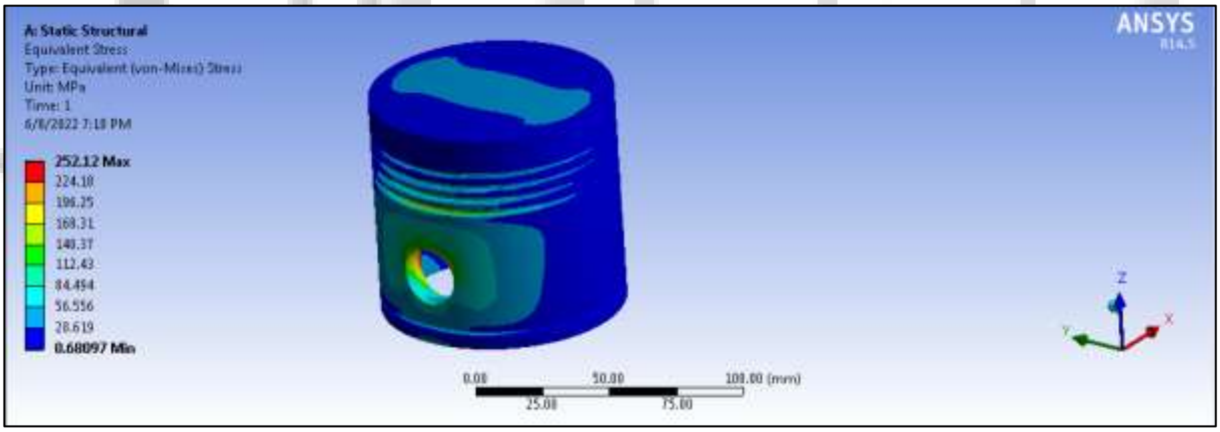
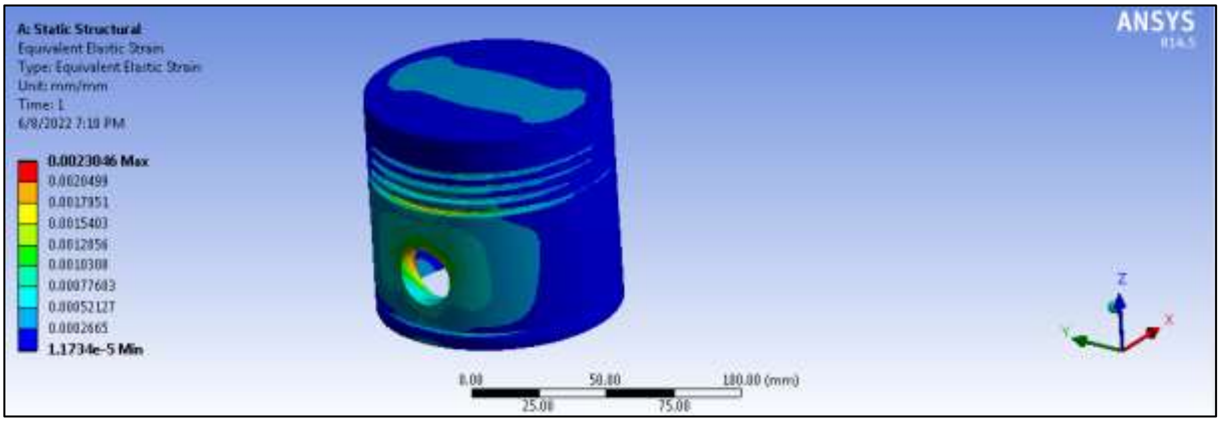
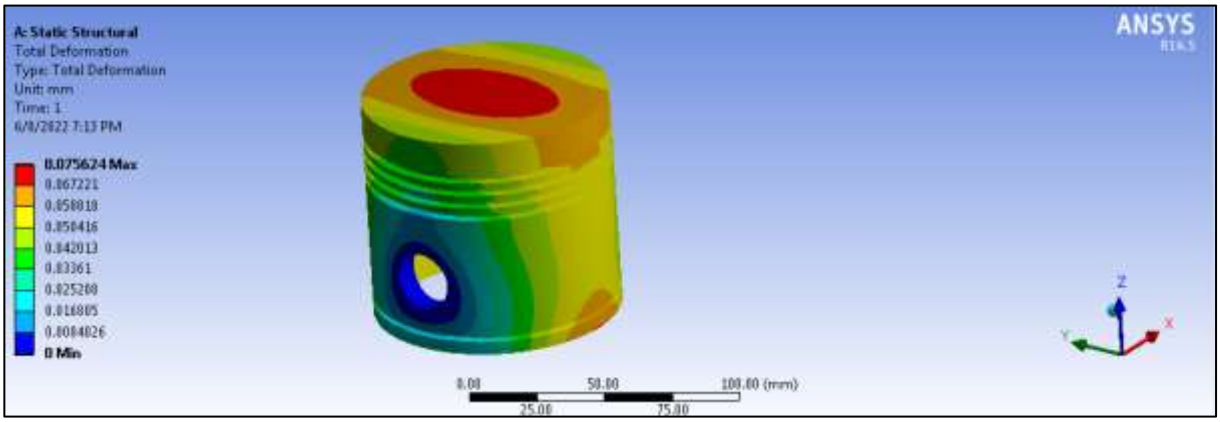


Strain

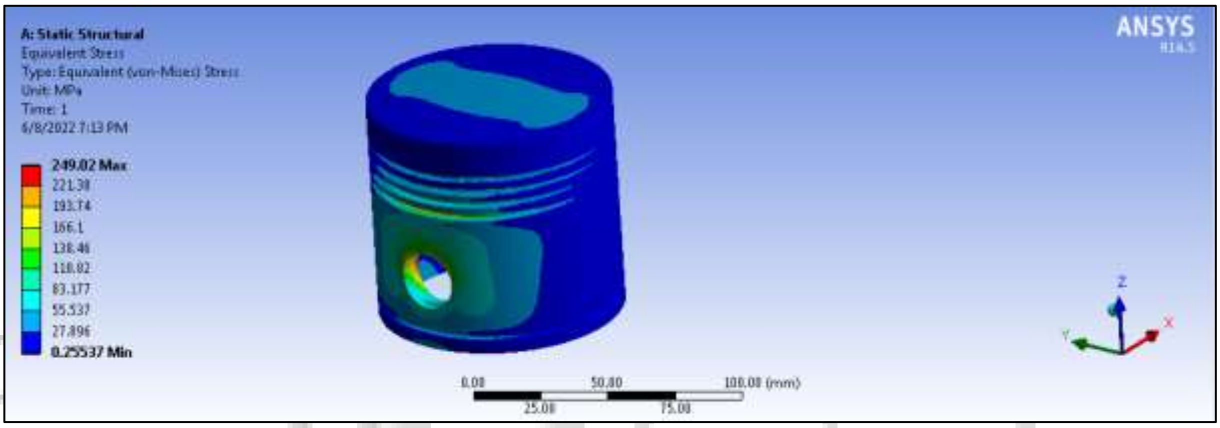


Material: aluminum alloy

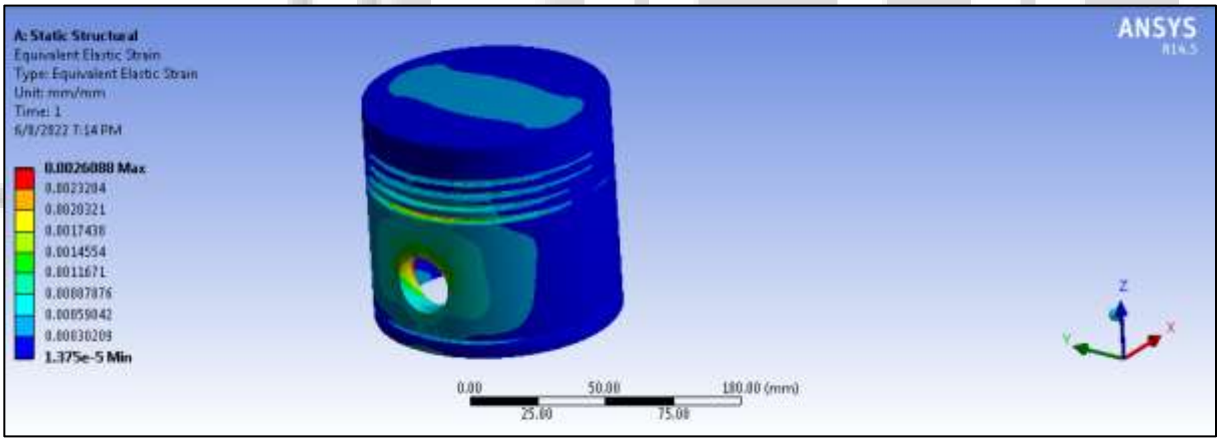
Total deformation



Stress

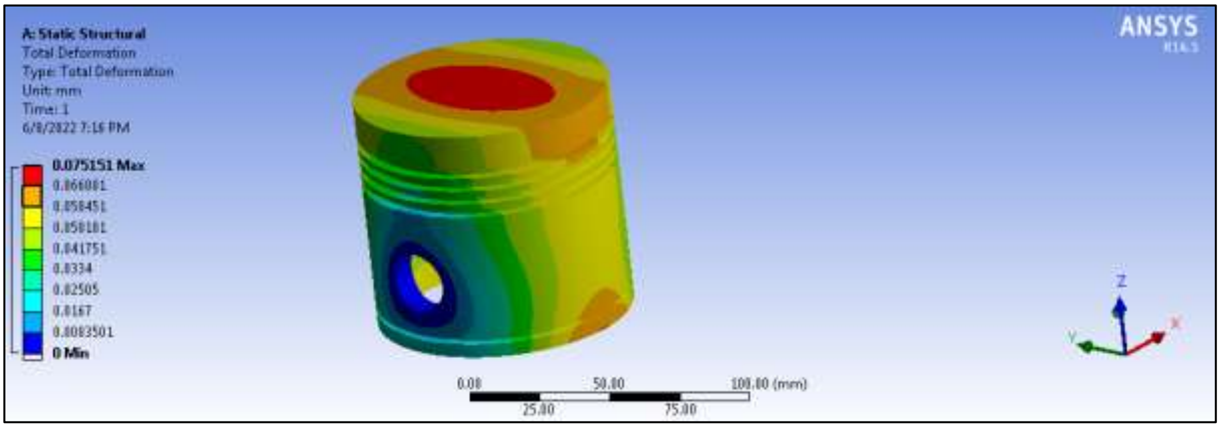


Strain

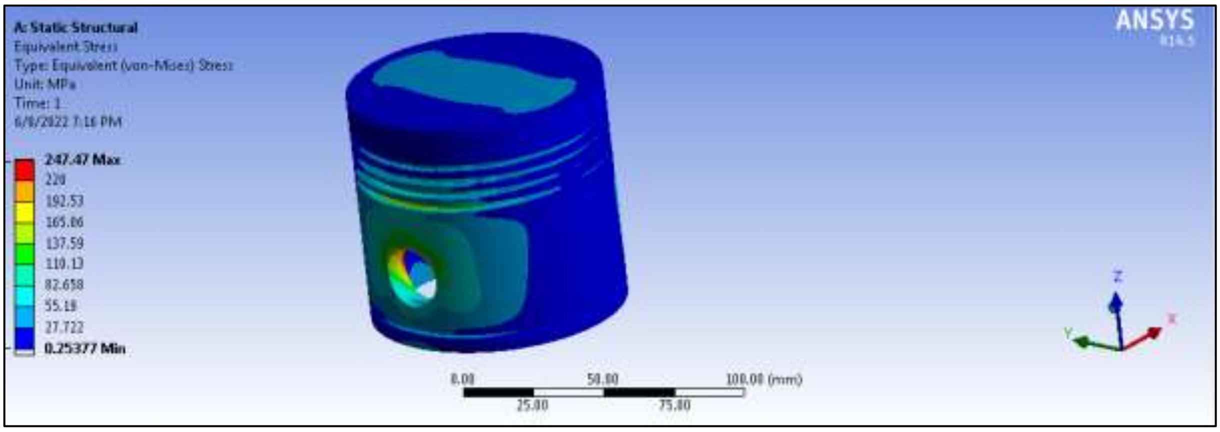


Material-Al with SiC coated

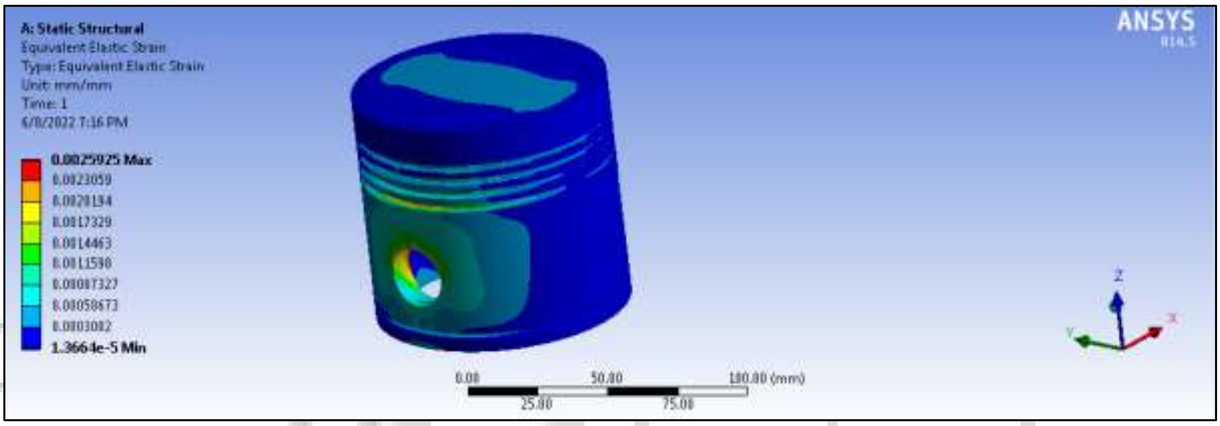
Total deformation



Stress

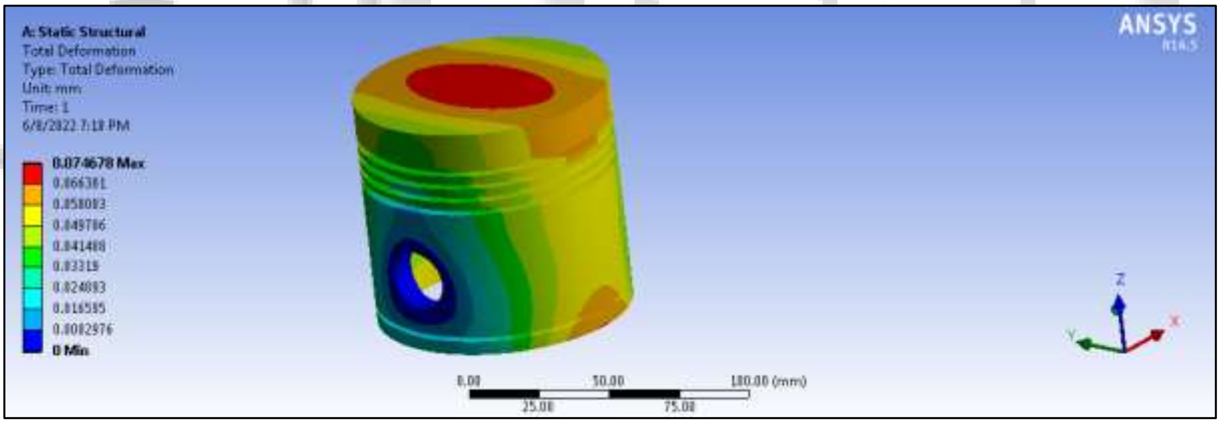


Strain

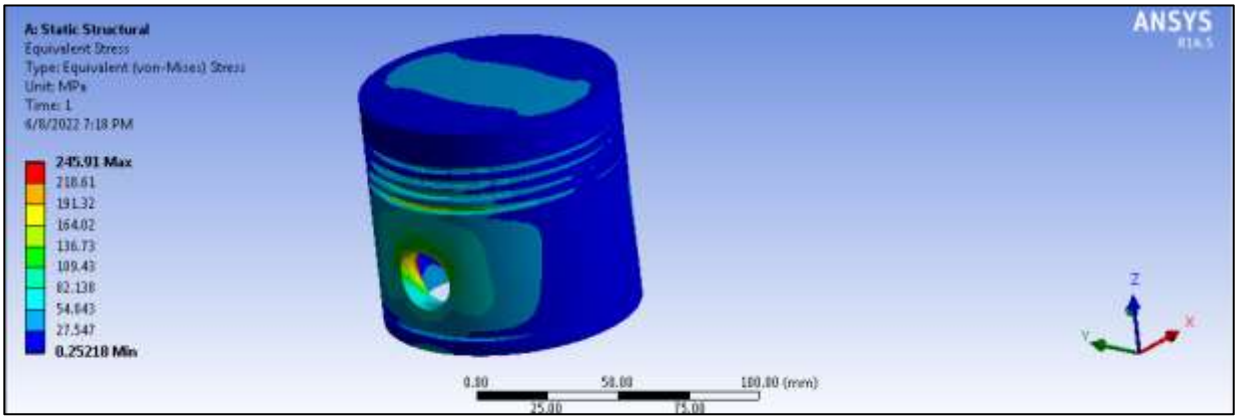


Material-Al with Titanium coated

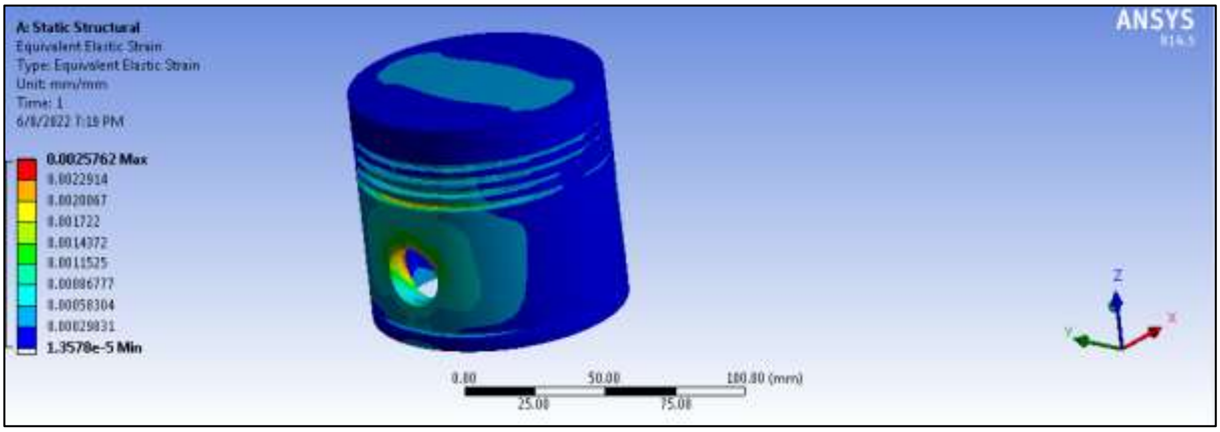
Total deformation



Stress

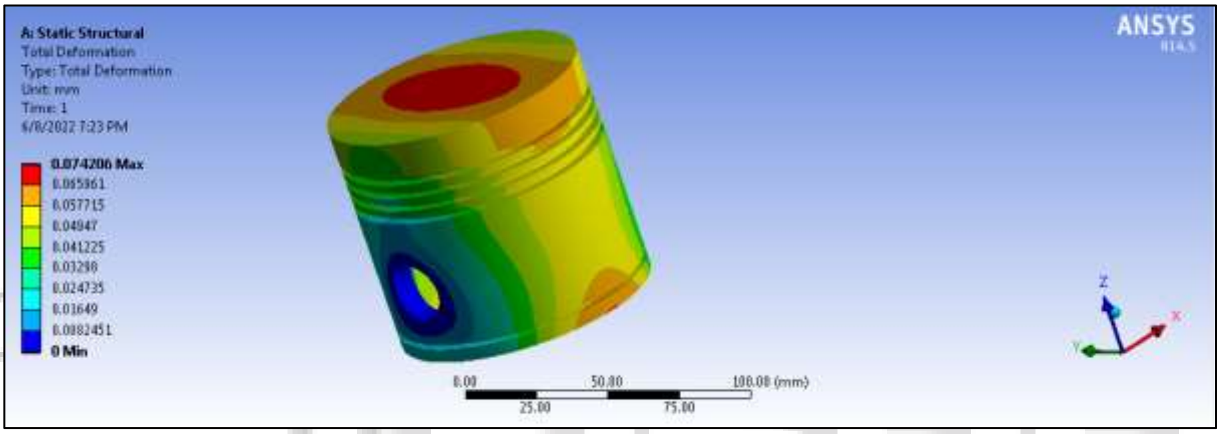


Strain

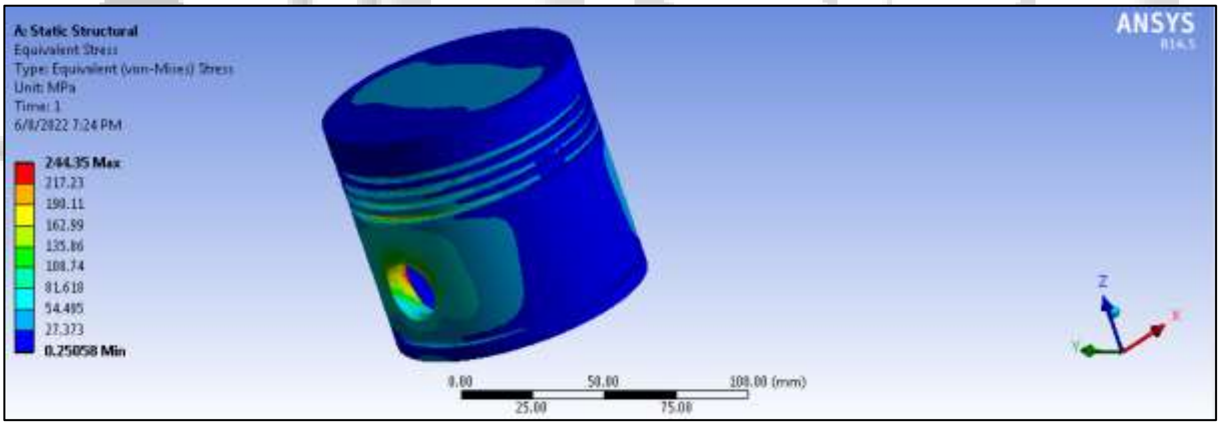


Material-Al with Nickel coated

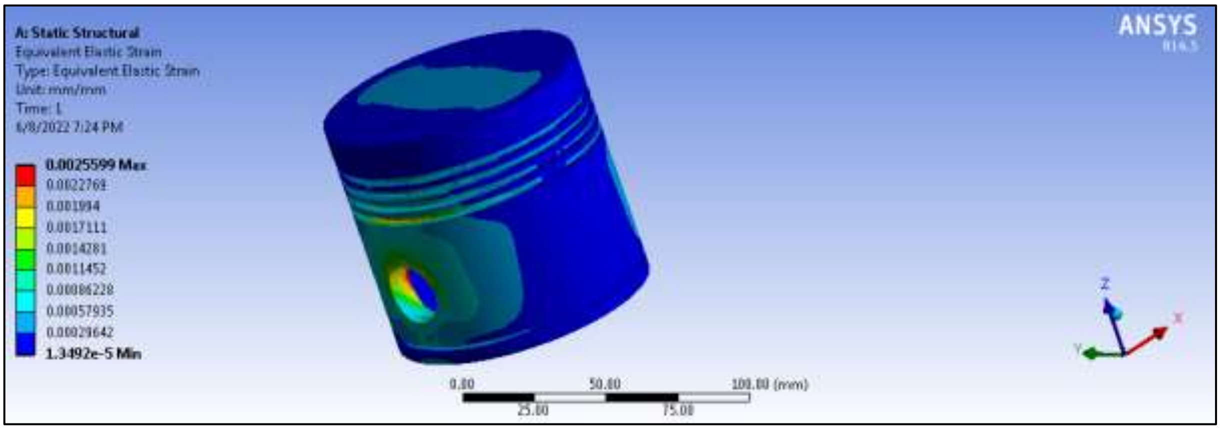
Total deformation



Stress

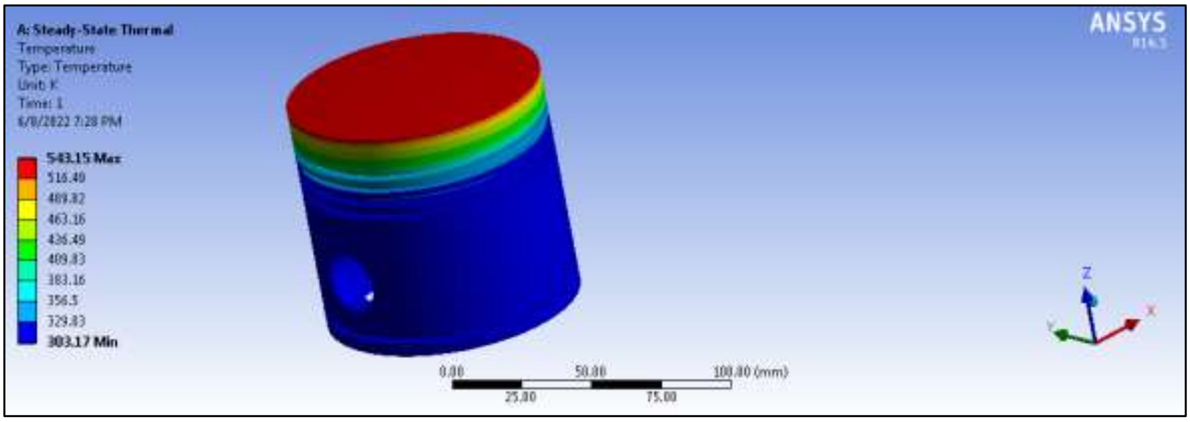


Strain

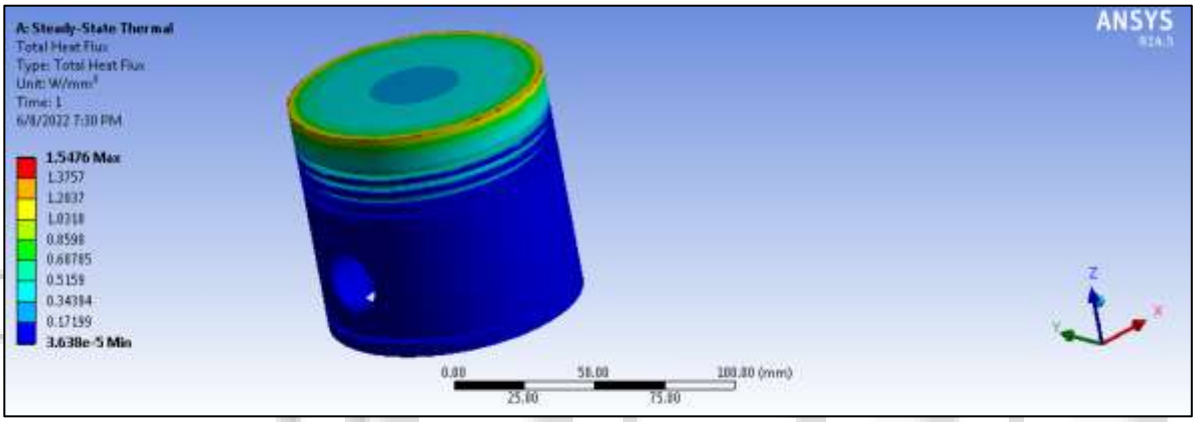


THERMAL ANALYSIS OF TBC PISTON

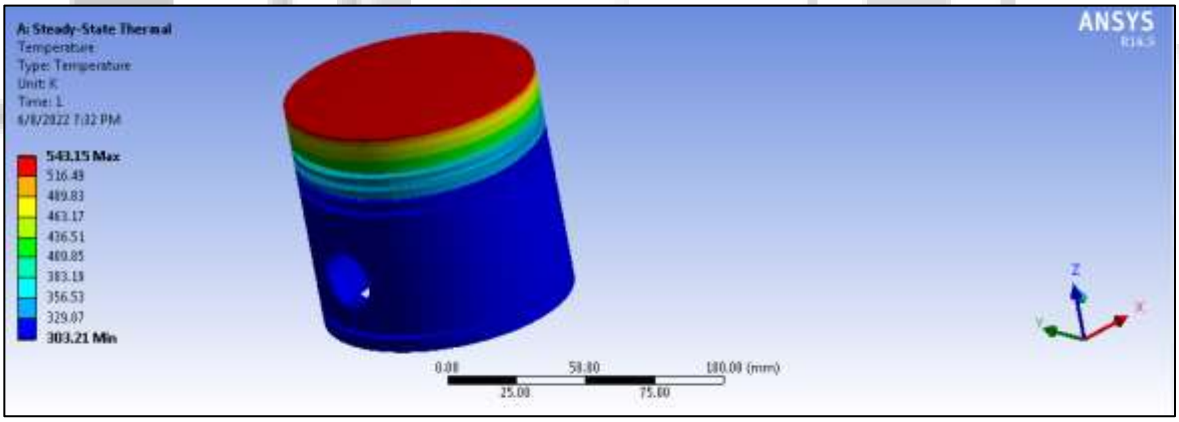
MATERIAL: CAST IRON
TEMPERATURE DISTRIBUTION



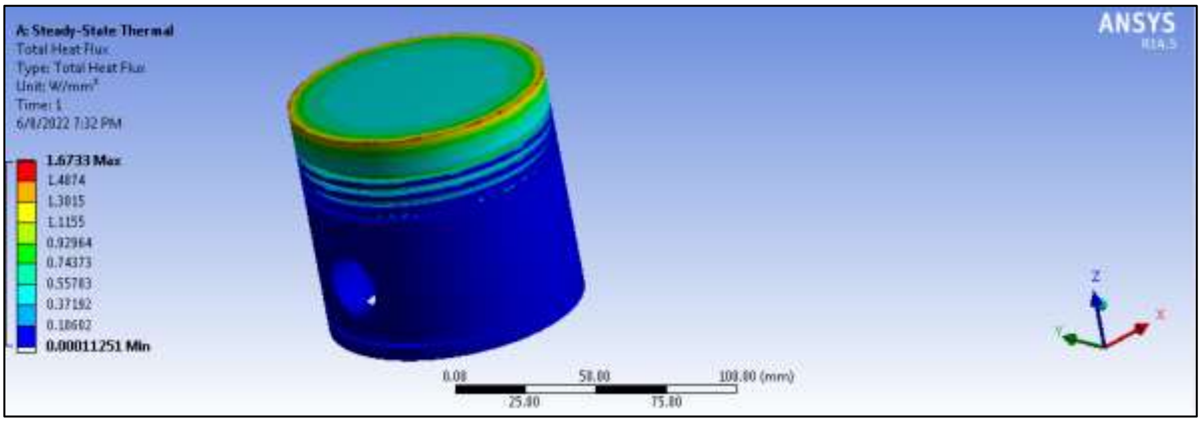
HEAT FLUX



Material-cast-iron with SiC coated
TEMPERATURE DISTRIBUTION

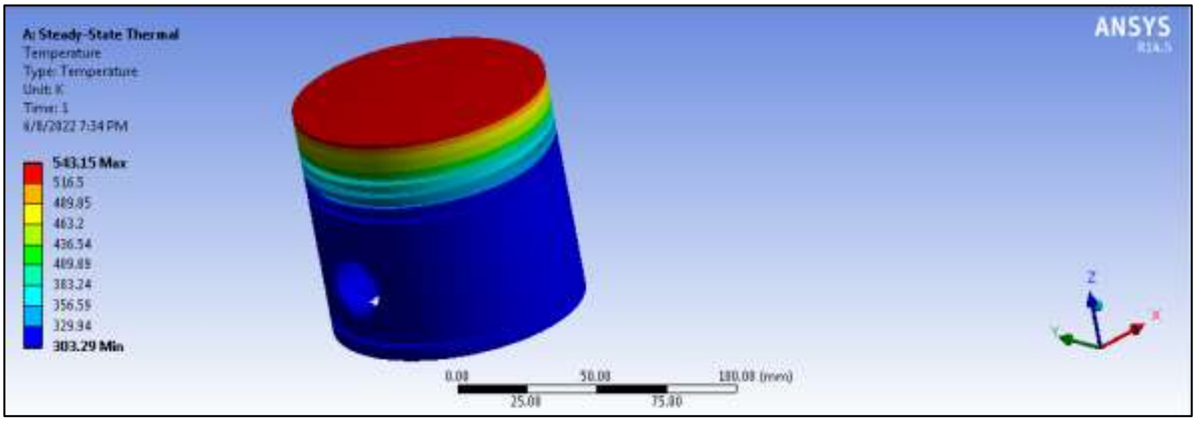


HEAT FLUX

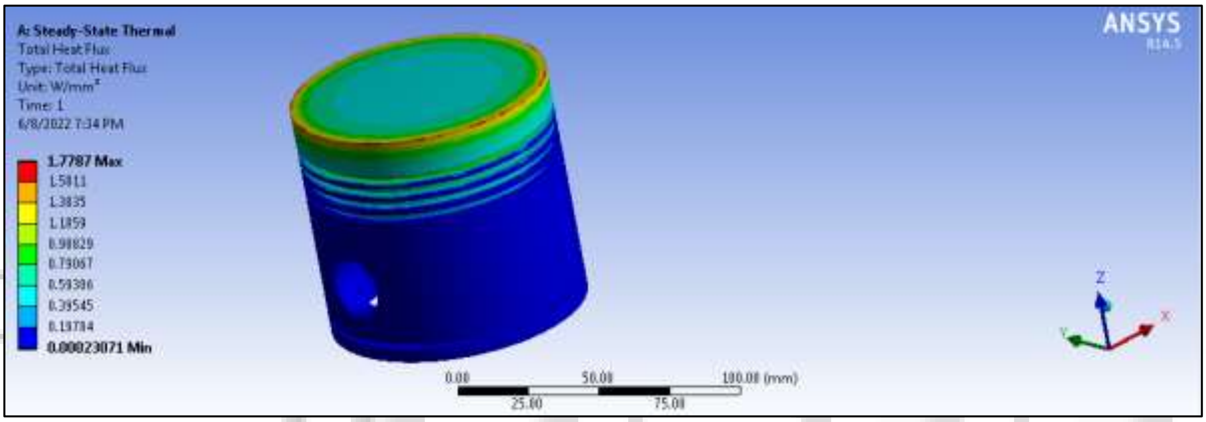


MATERIAL: Material-cast-iron with Titanium coated

TEMPERATURE DISTRIBUTION

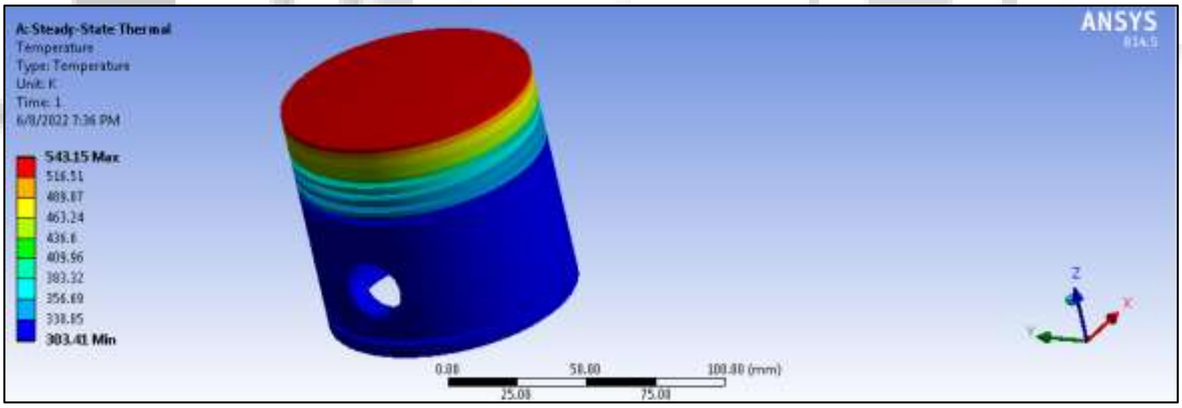


HEAT FLUX

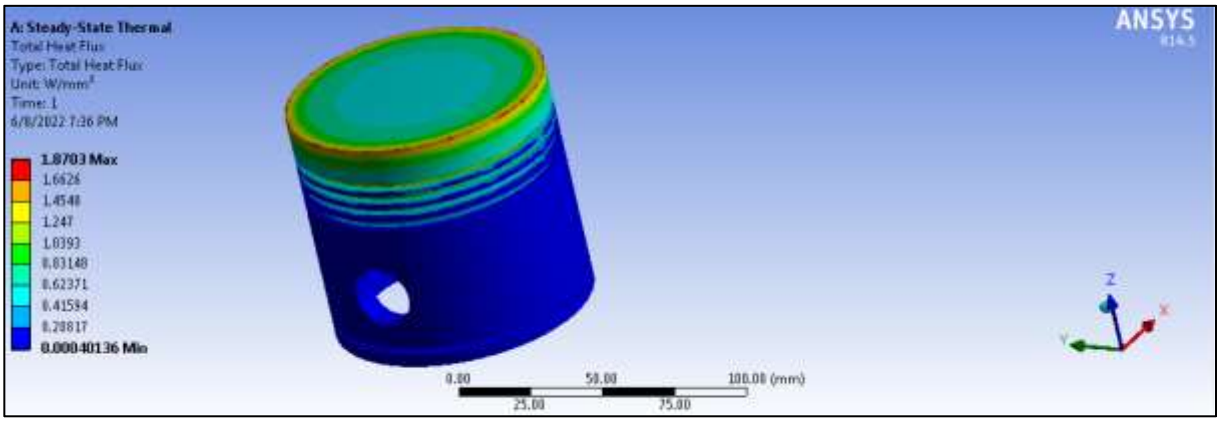


MATERIAL: Material-cast-iron with Nickel coated

TEMPERATURE DISTRIBUTION

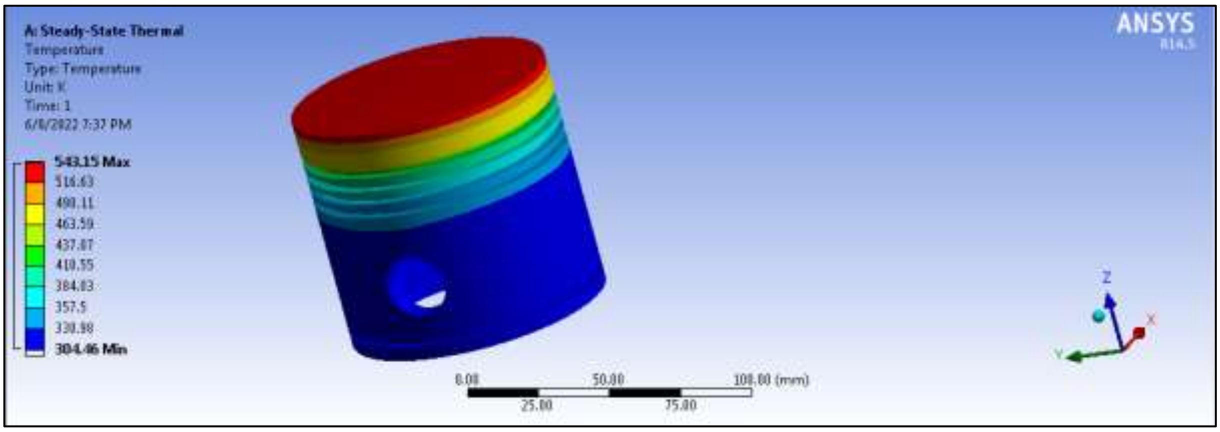


HEAT FLUX

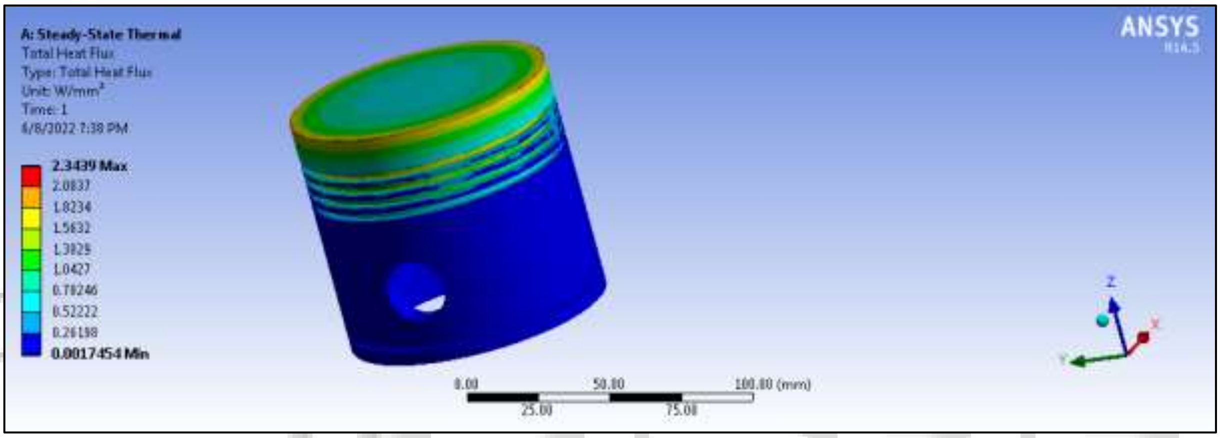


MATERIAL: ALUMINUM ALLOY

TEMPERATURE DISTRIBUTION

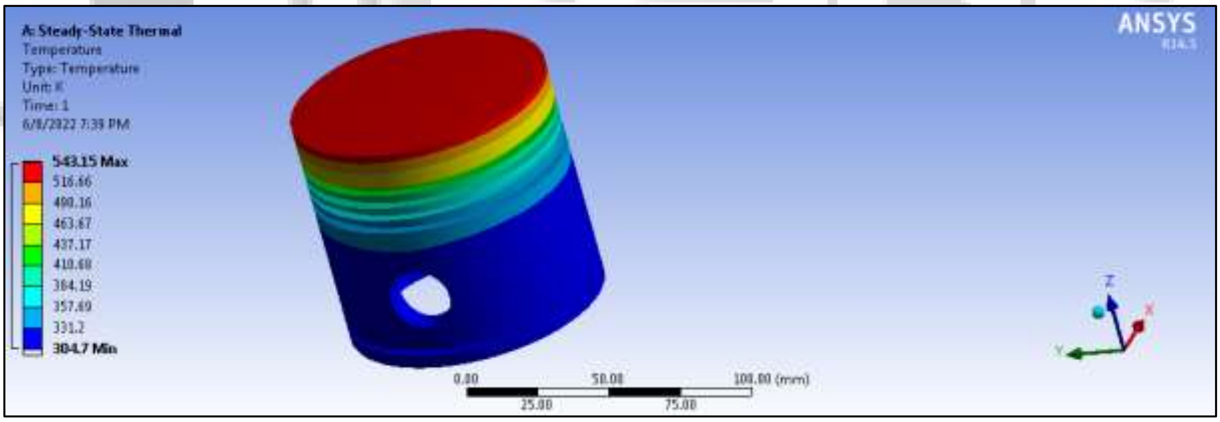


HEAT FLUX



MATERIAL: Al with SiC coated

TEMPERATURE DISTRIBUTION



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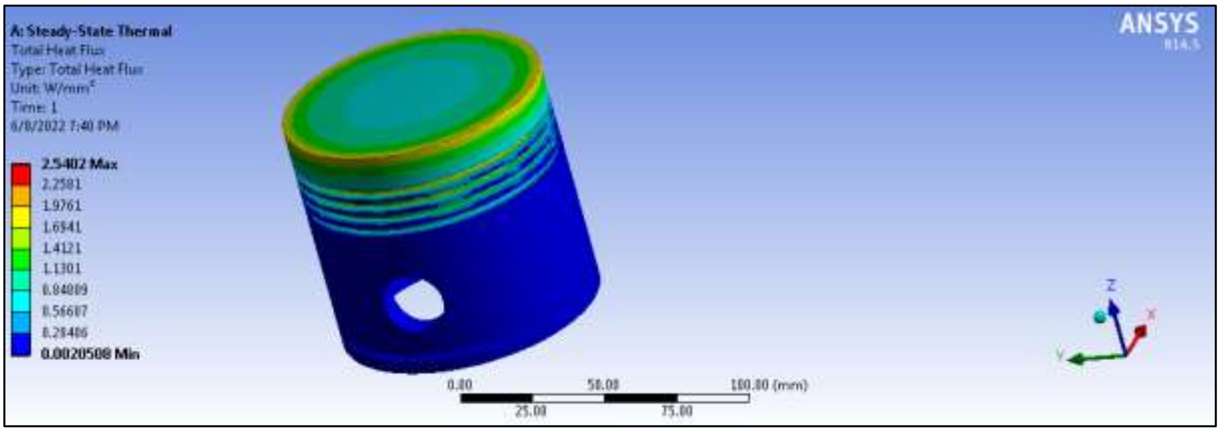
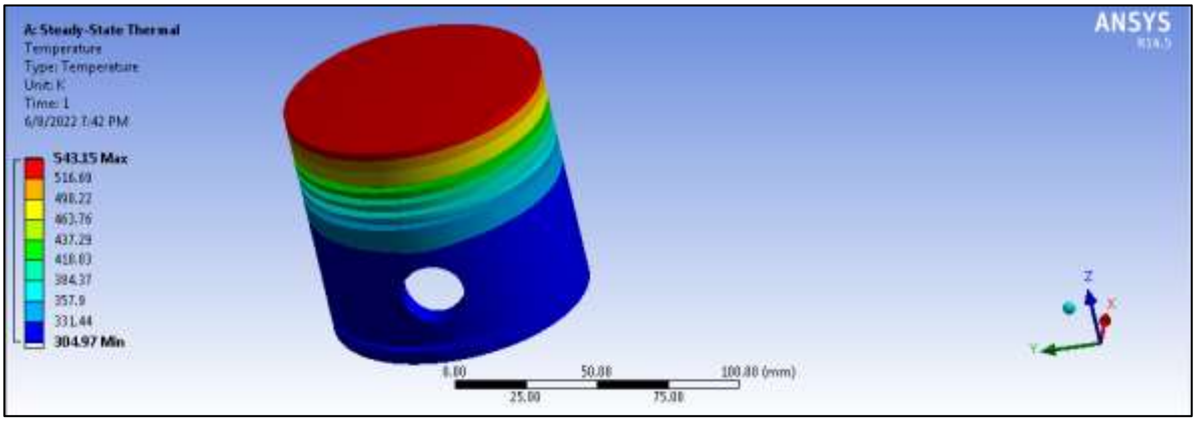
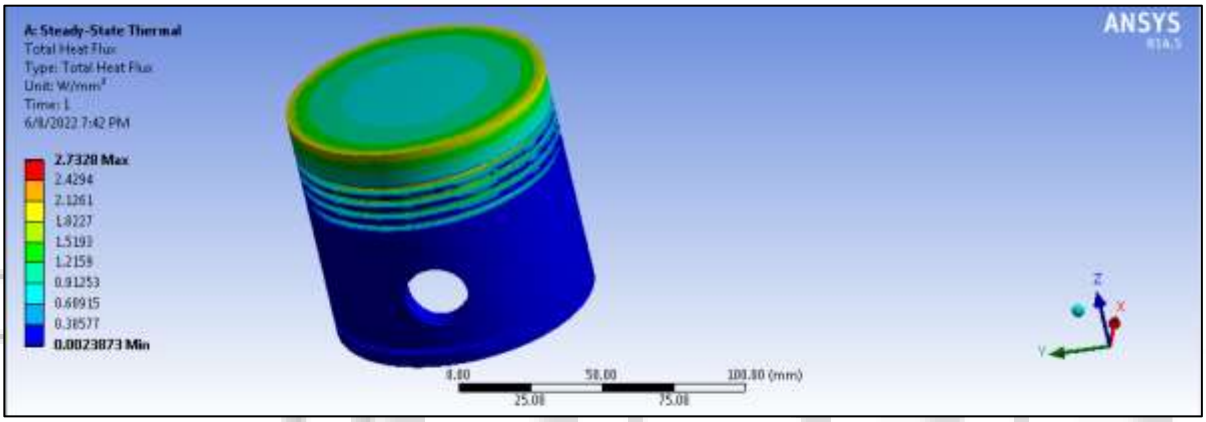


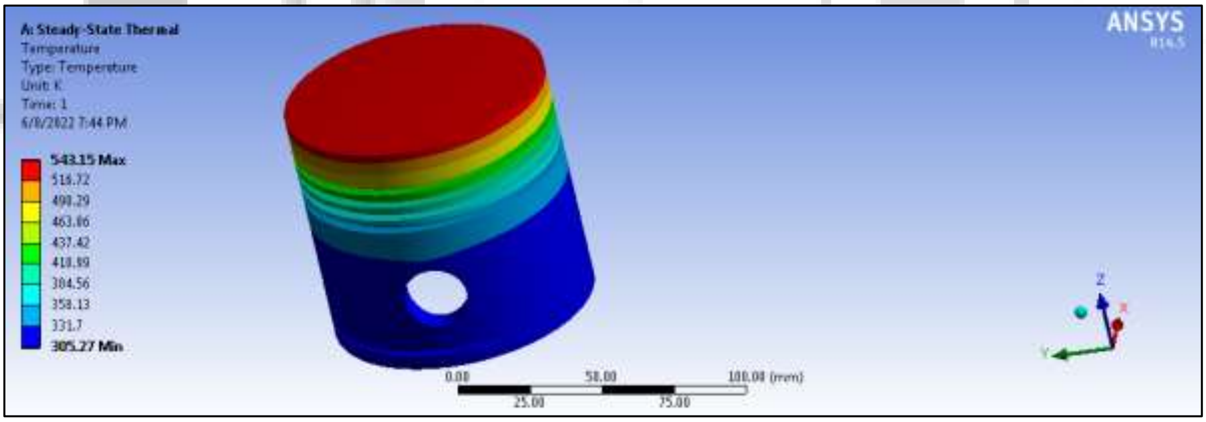
MATERIAL: Al with Titanium coated
TEMPERATURE DISTRIBUTION



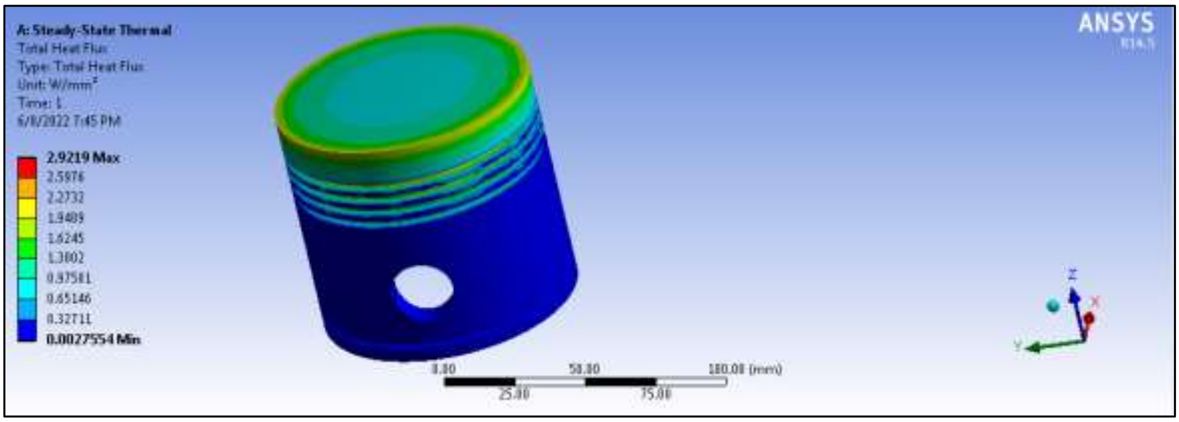
HEAT FLUX



MATERIAL: Al with Nickel coated
TEMPERATURE DISTRIBUTION



HEAT FLUX



V. Results and Discussions

Static Analysis Results

Materials	Total deformation (mm)	Stress (N/mm^2)	Strain
Cast iron	0.068147	261.63	0.0023916
cast-iron with SiC coated	0.066908	256.688	0.002348
cast-iron with Titanium coated	0.066498	255.29	0.002336
cast-iron with Nickel coated	0.065669	252.12	0.0023046

Materials	Total deformation (mm)	Stress (N/mm^2)	Strain
Aluminum alloy	0.075624	249.02	0.0026088
Aluminum alloy with SiC coated	0.075151	247.47	0.0025921
Aluminum alloy with Titanium coated	0.074678	245.91	0.0025762
Aluminum alloy with Nickel coated	0.074206	244.35	0.0025599

Thermal analysis results

Materials	Heat flux(w/mm^2)
Cast iron	1.5476
cast-iron with SiC coated	1.6753
cast-iron with Titanium coated	1.7787
cast-iron with Nickel coated	1.8703

Materials	Heat flux(w/mm^2)
Aluminum alloy	2.34
Aluminum alloy with SiC coated	2.54
Aluminum alloy with Titanium coated	2.73
Aluminum alloy with Nickel coated	2.92

VI. Conclusion

This project work is based on bi-metallic piston used in automobile. There are lots of thermal barrier coated materials used in automobile application. In this case, piston is identified with two metals. It reduces the thermal stress in the material to overcome this serious problem. Here in this thesis we have designed two different model pistons using CAD software – CATIA and Thermal analysis is done using two different materials i.e., AL 7075 and Cast iron coated with different materials such as SiC, titaunum and Nickel.

Along with cast iron, complete cast-iron model and model using al7075 and coated are tested using Ansys 14.5.As from the results obtained, if we compare the values from tables and graphs, we can conclude that for both models TBC material has the life standard because develops very less stress when compared with aluminum and cast-iron.

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