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Thermal analysis on two wheeler piston with different materials by using FEA method

Neha Choubey[a,*], Ashish Kumar Shrivastava[b], Abhishek Choubey[b], Swapnil Singh[c], Balendra Bhaskar[d]

[a]*School of Applied Science and Language, VIT Bhopal, University, MP, India*
[b]*Department of Mechanical Engineering, Sistec R, Bhopal, MP, India*
[c]*Department of Mechanical Engineering, Rabindranath Tagore University, Bhopal, MP, India*
[d]*Department of Mechanical Engineering, NIMS University Jaipur Rajasthan India*

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Abstract

The piston is thought to be a standout amongst the most essential parts in a reciprocating engine, reciprocating pumps, gas blowers and pneumatic barrels, among other comparable mechanisms. As most critical part, is that less time is required to outline the cylinder and simply a couple of essential details of the engine. Actually, due to high heat transfer through the piston, the outer shape of the piston crown will be deformed. So due to this problem here computational testing has been performed on ANSYS simulation software with three different materials and observed that stress of piston with ALSI AI alloy has maximum stress of $50.79Mpa$ piston made of M-124 cast AL composite stress value is $50.54Mpa$. Furthermore, maximum stress on M-124 forged AL alloy is found to be $50.23Mpa$ and here observe that in case of deformation, piston made of ALSI AI alloy found to have maximum deformation of $1.06mm$ and when piston made of M-124 cast AL combination then maximum deformation is $0.88mm$. What's more, maximum deformation on M-124 forged AL alloy is found to be $0.086mm$ and here observe that in case of heat flux, piston made of ALSI AI alloy is found to have maximum heat transfer of $3.3w/mm^2$ is observed. When piston made of M-124 cast AL combination then maximum heat transfer of $3.4w//mm^2$ and maximum heat flux on M-124 forged AL alloy is found to be $3.6w/mm^2$. So the aluminium alloy M-124 is the best manufactured composite material So this material is suggested for manufacturing work.

Keywords: reciprocating engine, Thermal analysis, Wheeler Piston
2010 MSC: 97M10, 74-XX

1 Introduction

The drop of pollutant emissions from internal combustion engines (ICE) in order to cover up all emissions legislations is at present one of the most important challenges for the automotive industry and engineers [1]. Several works can be found in the literature where researchers have paying attention on the application of new design strategies [1].

*Corresponding author
Email addresses: neha.choubey@vitbhopal.ac.in (Neha Choubey), ashish.shri.nri@gmail.com (Ashish Kumar Shrivastava), abhishekchby2@gmail.com (Abhishek Choubey), swapnilsingh066@gmail.com (Swapnil Singh), balendra.dream@gmail.com (Balendra Bhaskar)

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The input energy of an internal combustion engine has three parts: energy used by coolant, energy which is utilized for valuable work and energy lost through exhaust and only 1/3 of the total energy is transformed to work. Thus the efficiency and overall performance of internal combustion engine can be increased by utilizing these heats lose into the useful work [2]. There are three main essentials when optimizing the performance of Internal Combustion (IC) engines in terms of enhanced energy effectiveness. Firstly, it is essential to decrease the thermal losses, which according to Richardson [3] account for 50–60 percentage of all the losses. Secondly, frictional and pumping losses in load bearing conjunctions such as the piston-cylinder system, valve train and engine bearings represent 15–20 percentage of all the parasitic losses. Nearly 45 percentage of these losses can be attributed to the cylinder system, 30–45 percentage of which is due to the ring-pack.[4] The piston is one of the major stressed elements of an engine because it is located in the cylinder that has process. Therefore, it is must be de-signed to resist from harm that caused of the intense heat and pressure of process. There are several damages or failures for piston due to extreme pressure and heat like piston seizing, piston ring damage and cylinder spoil. The amount of stress that obtained the damages can be determined by using finite element analysis (FEM). With finite element method, the stresses amounts that operate to the piston is calculated by simulation. Thus, it can decrease the expenditure and time due to manufacturing the components and the similar time it can better the value or quality of the piston. The thermal boundary layer is very essential for the cylinder; it colder than the bulk of the charge, the local heat release is delayed close to the walls.[5] To reduce heat transmit and get better the result of an internal combustion engine a technology of insulating the piston, cylinder head and combustion chamber, with thermal coating materials has been introduced. Engine is a heart of the vehicle and piston is the main component of the engine. [6, 7] The piston ring is one of the most primary elements of an inner ignition system. Its principle of designs are to seal the ignition of the engine, limit the grinding against the chamber liner yet in addition heat move from the cylinder to the cooled chamber liner. Another significant property of the piston ring is to equitably convey oil along the chamber liner. Single cylinder in two-stroke diesel engine contains four to five cylinder rings to as the ring pack and for every one of the cylinder rings there is a comparing cylinder ring groove at the cylinder in which the cylinder ring is mounted. The top ring of the ring pack regularly has a base material of higher evaluation cast iron and in some cases the ring is thicker and higher than the other cylinder rings in the ring pack. Piston rings are placed at top dead centre of piston. At the point when the engine is damaged the single cylinder ring is just influenced by the contact surfaces against the chamber liner and the cylinder ring groove. It may, when the engine is running the cylinder ring pack is likewise influenced by gas pressures and temperature coming about because of pressure and burning. The chamber pressure follows up on the upper portion of the top cylinder ring and a small part of the chamber pressure acts underneath the top cylinder ring. Real working conditions of piston can demonstrate in Fig. 1

This figure is describing about nomenclature to two wheeler piston.

2 Materials

Materials Consideration:
In this work we have selected three different materials for analysis.

• Aluminium Alloy ALSI • M-124 Cast Al alloy • M-124 Forged Al alloy

Aluminium- alloy ALSI:

Aluminium-Silicon (AI-Si) alloys are most versatile materials, comprising $85 to 90$ percentage of the total aluminium cast parts produced for the automotive industry. Depending on the Si concentration in weight percent (wt.percentage), [8]

M-124 Cast Al alloy:

The alloy M124 is also a refined state (M124V). The eutectic composition between Al-Si solid solutions, which develop as dendrites, it is made particularly fine by the addition of small amounts of sodium or strontium, the machinability is improved, but resistance to wear is worse than for grainy eutectic structures.[9]

M-124 Forged Al alloy:

The structures of the forged alloys M124P, M124VP, and the Al Cu alloy M-SP25 are also illustrated.[9]

3 Modelling and simulation

Finite Element Method:

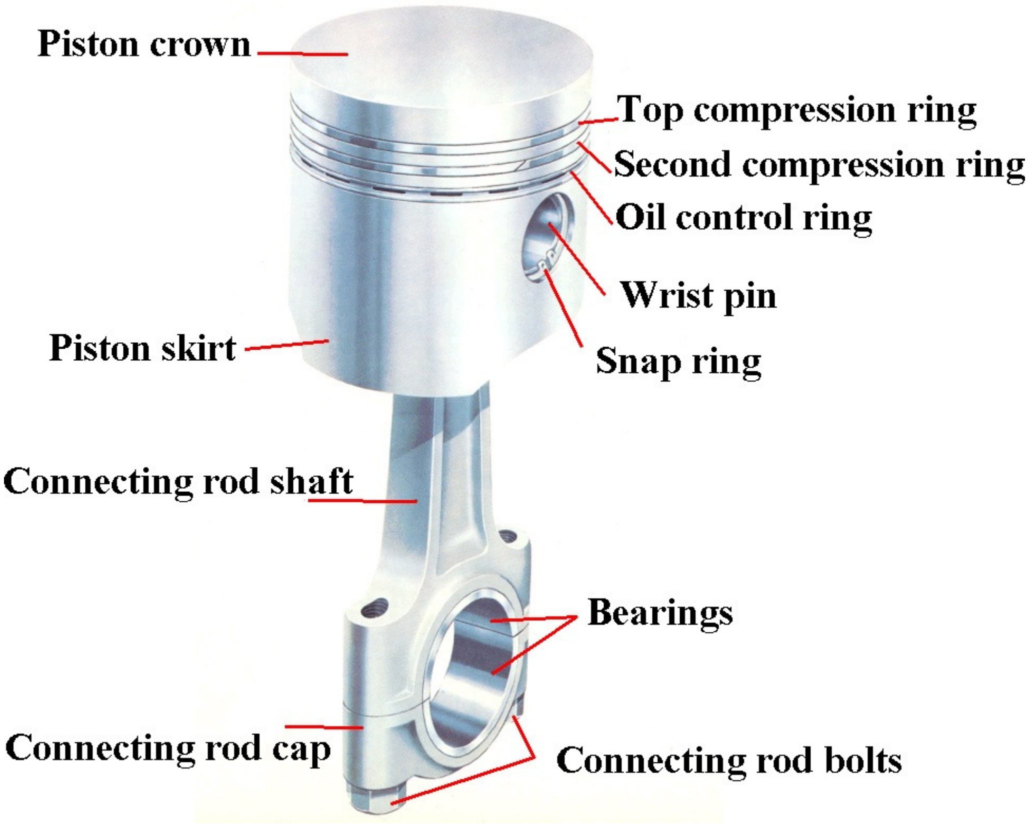

Figure 1: Piston

Finite element methods for solving partial differential equations use weighted residual concepts. The idea behind the finite element method is to break the spatial domain up into a number of simple geometric elements such as triangles or quadrilaterals. The weighted residual concept is then used to approximate the solution function over each finite element domain. Care needs to be taken to ensure continuity of the dependent variables and their first partials in moving from element to element. Partial differential equations are therefore transformed into sets of ordinary differential equations in time. The method is particularly suited for solving problems involving irregular geometries and steep gradient.[10]

Mesh: Actually here tetrahedral meshing used to automatic meshing generation with elements size 2 mm and 42564 nodes and 21023 elements taken into consideration.

Two wheeler engine piston is used for FEM analysis

Table 1: Specifications

S.No.	Parameters	Description
1	Engine Type	Air-cooled, 4-stroke single cylinder OHC
2	Displacement	124 cc
3	Maximum Power	10.74 PS or 7.8 kw @ 7500 rpm
4	Maximum Torque	11 N-m @ 6000 rpm
5	Compression Ratio	9.9 : 1
6	Starting	Kick Start / Self Start
7	Ignition	DC - Digital CDI
8	Bore	50 mm

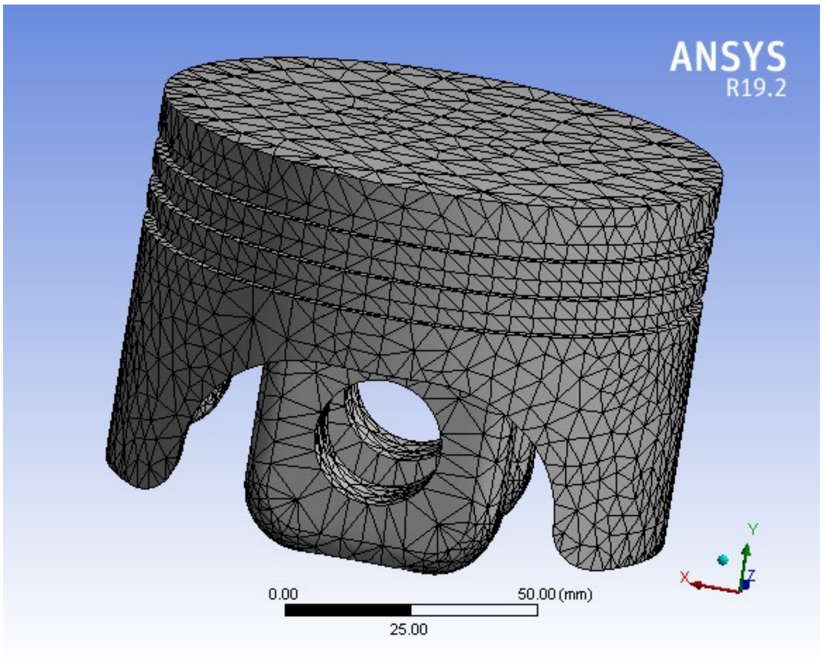

Figure 2: Meshing

Model has created on Solid work software then it is imported in ANSYS software for creating meshing through finite element method with tetrahedral type mesh is created in the figure 2.

Load and Boundary Condition: Here 6 Mpa pressure has applied on piston head and 40^0C atmospheric temperature, 5e-006 w/mm2 0c fluid film coefficient, heat flow 2238 W and temperature distribution on piston rings 100^0C, 150^0C, 200^0C and 300^0C.

4 Result and Discussion

Result: In this analysis we consider three different materials ALSI AI composite, M-124 cast AL alloy and M-124 forged AL alloy for FEM analysis and found that M-124 forged alloy is best suitable material compare to the other two materials because it has more heat transfer rate than others. We have observed that stress of piston with ALSI AI alloy have maximum stress of 50.79 Mpa, piston made of M-124 cast AL composite stress value is 50.54 Mpa. Maximum stress on M-124 forged AL alloy is $50-23$ Mpa. In case of piston made of ALSI AI alloy have a deformation of $1.06mm$, piston made of M-124 cast AL composite deformation is 0.88 mm, deformation on M-124 forged AL alloy is found to be $0.086mm$ and in case of heat flux, piston made of ALSI AI alloy heat flux is $3.3W/mm^2$, piston made of M-124 cast AL combination maximum heat flux is $3.4W/mm^2$ and heat flux on M-124 forged AL alloy is found to be $3.6W/mm^2$.

Discussion: It tends to be seen that greatest stress force is on the base surface of the chamber crown in every one of the materials. Here we picked aluminium alloy M-124 manufactured composite material this material has more heat alteration than other different materials. In this study piston analysis by computational techniques are carried out. Piston made of various materials like Aluminium Alloy M-124 CAST and M-124 AL fashioned compound and investigated effectively. Thermal transient analysis is performed by help of ANSYS 19.2 software and according to the result aluminium alloy M-124 is best manufactured composite material for piston, so this material is suggested for manufacturing work.

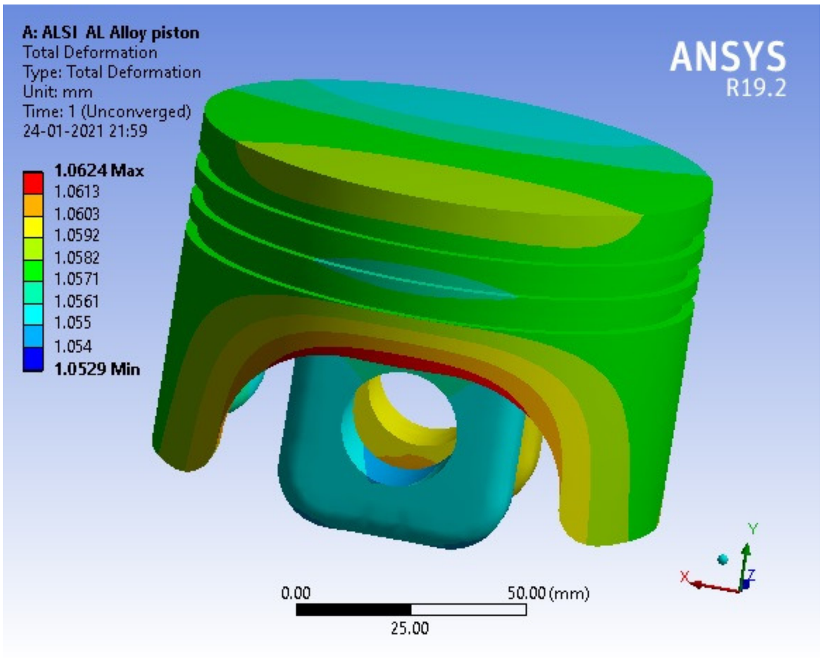

Figure 3: Total Deformation Aluminium Alloy Materials

Here we can see the deformation results in figure 3 of Aluminium Alloy ALSI materials piston crown.

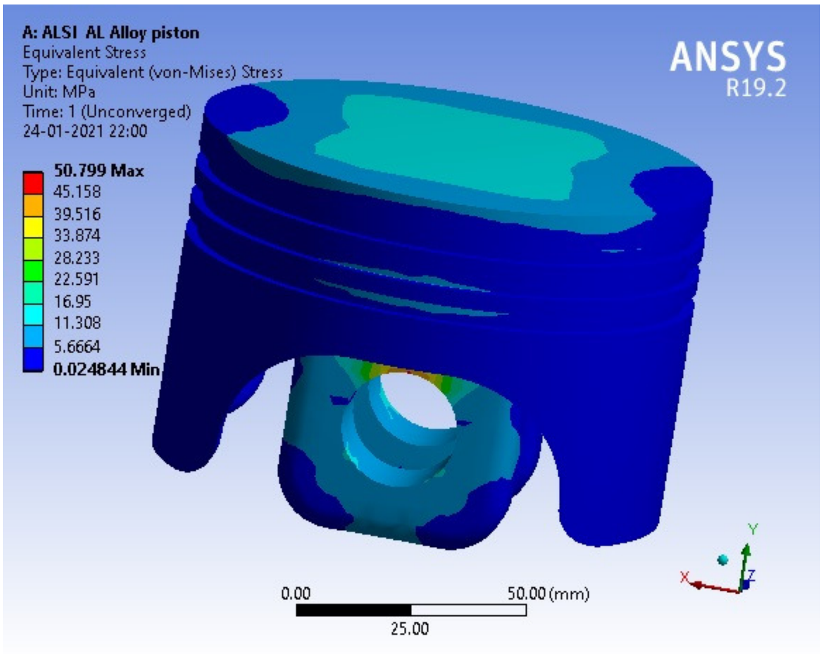

Figure 4: Equivalent Stress Aluminium Alloy Materials

The above figure 4 show the equivalent Stress result for Aluminium Alloy ALSI materials piston crown.

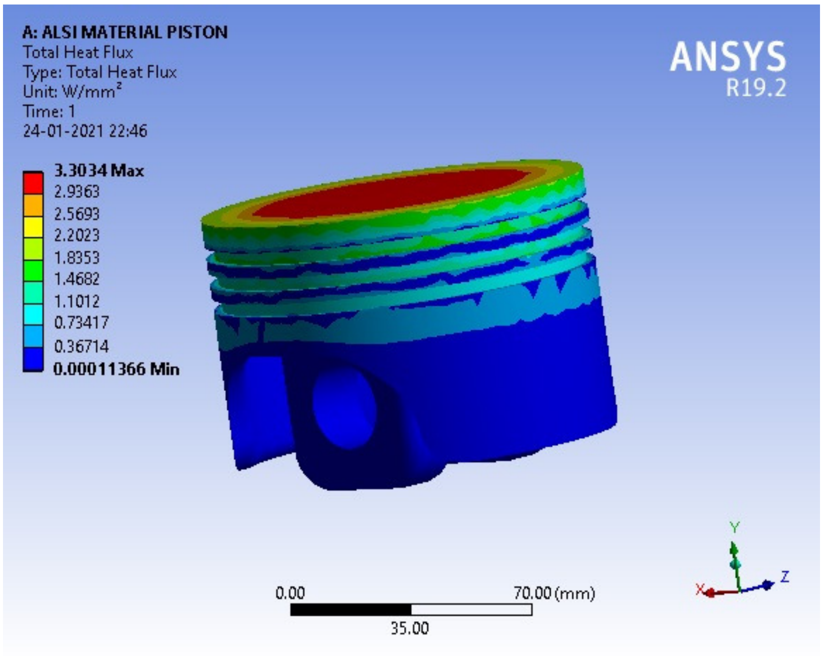

Figure 5: Total Heat Flux Aluminium Alloy ALSI

This figure 5 represent the heat generation results for Aluminum Al-loy ALSI materials piston crown with help of finite element computational programming.

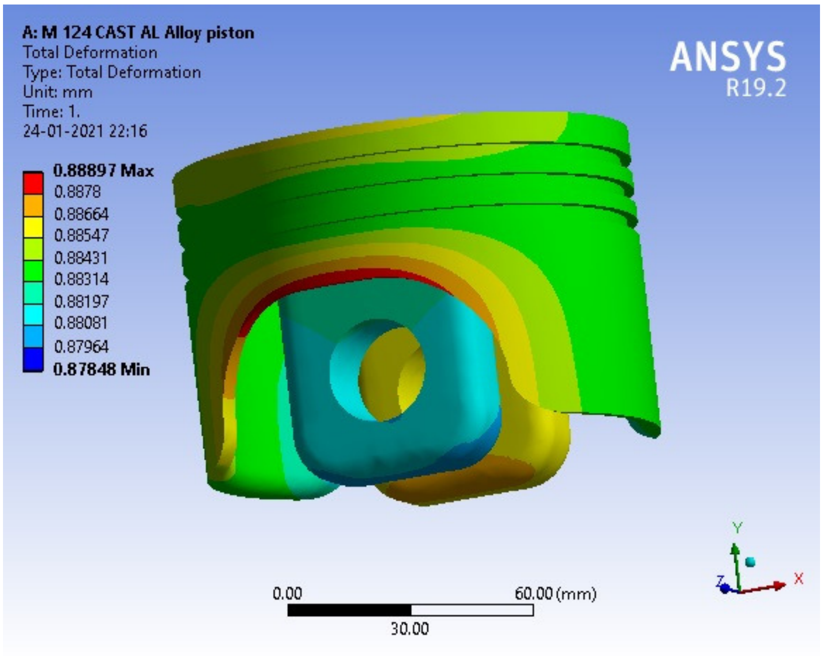

Figure 6: Total Deformation M-124 CAST AI Alloy Materials

This figure 6 show the deformation results for M-124 Cast Al Alloy piston crown.

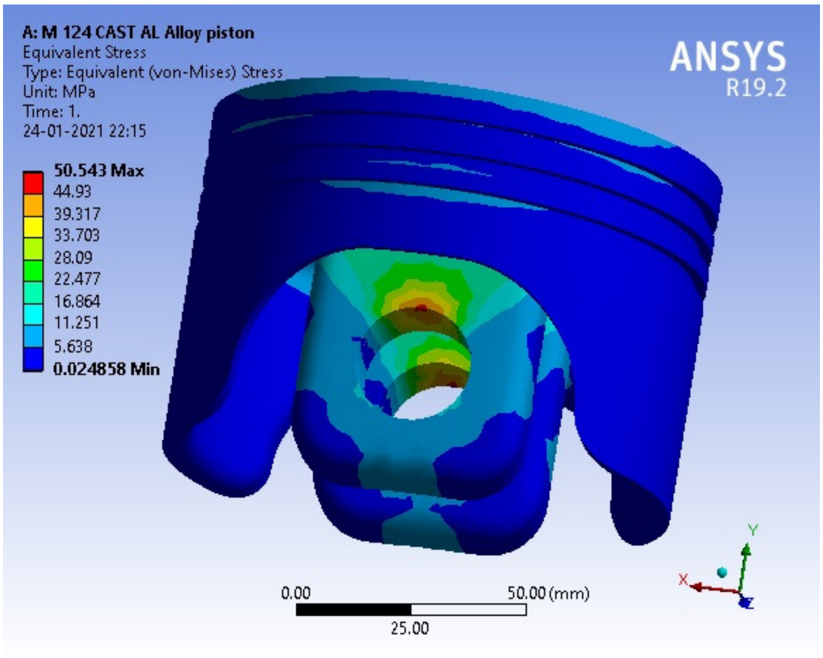

Figure 7: Thermal Stress M-124 CAST AI Alloy Materials

This figure 7 shows that M-124 Cast Al Alloy piston crown of equivalent Stress results.

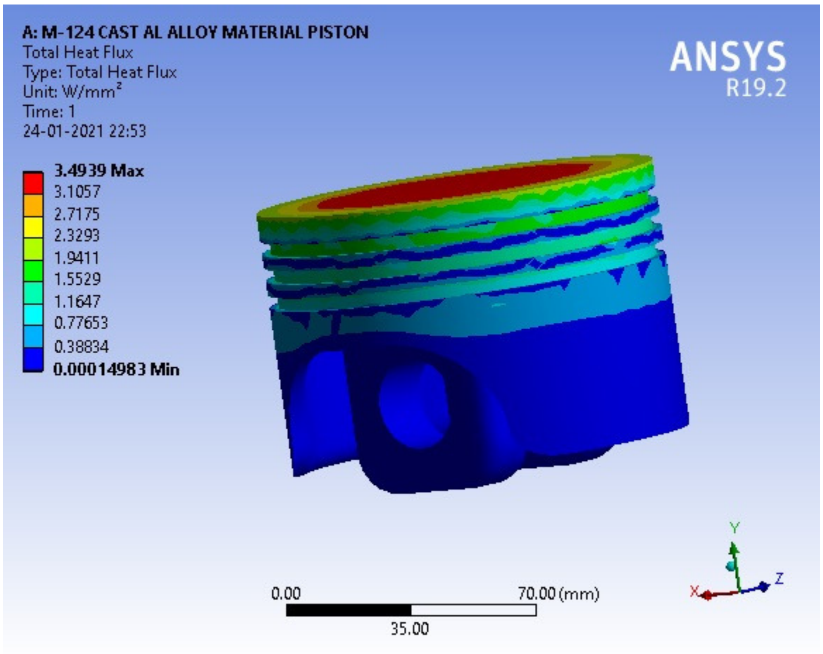

Figure 8: Total Heat Flux M-124 CAST AI Alloy Materials

This figure 8 represent the heat generation in M-124 Cast Al Alloy materials piston crown by FEM analysis.

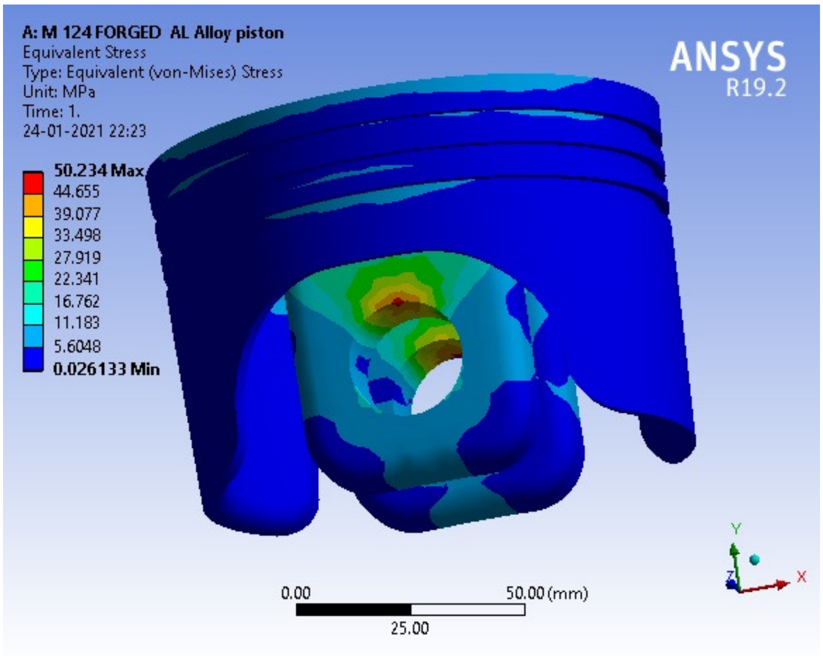

Figure 9: Equivalent Stress M-124 FORGED AI Alloy Materials

Here figure 9 shows that the equivalent stress on piston crown of M-124 forged Al Alloy.

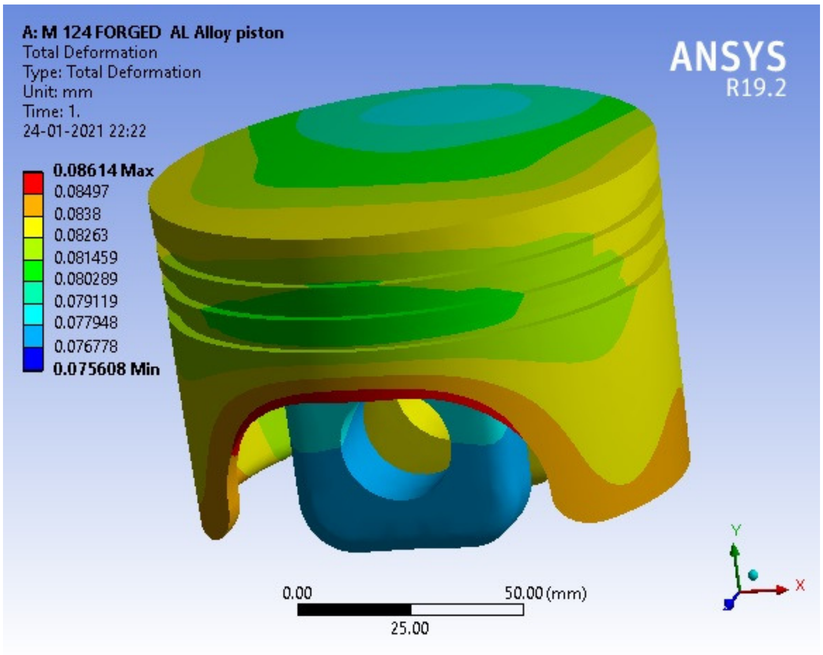

Figure 10: Total Deformation M-124 FORGED AI Alloy Materials

Figure 10 represent the deformation results of M-124 forged Al Alloy piston crown generated by finite element computational programming.

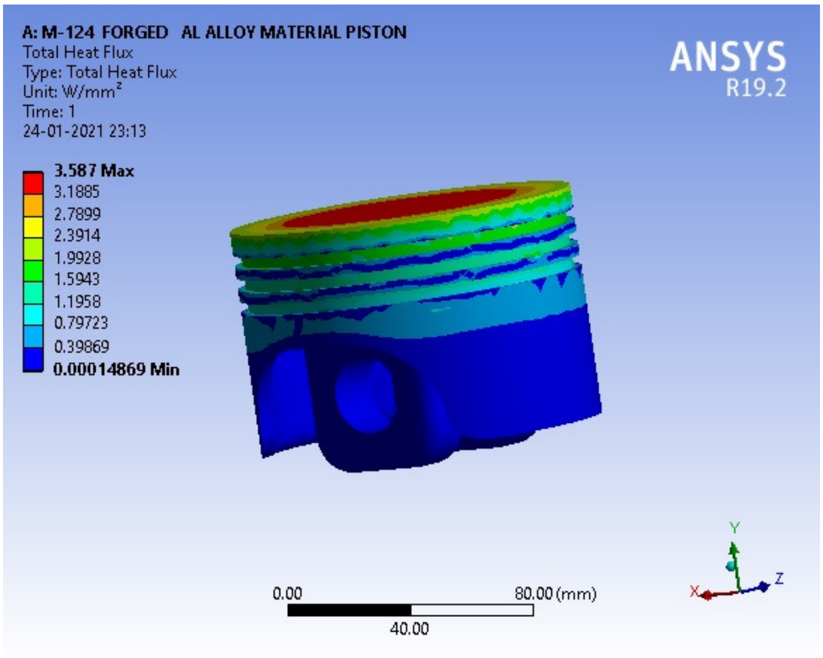

Figure 11: Total Heat Flux M-124 FORGED AI Alloy Materials

In this $figure 11$ we can see the heat generation results for M-124 forged Al Alloy materials piston crown.

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