SIMULATION AND ANALYSIS OF ALSI10MG ALLOY FOR PISTON MATERIAL IN ADDITIVE MANUFACTURING

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Abstract - **This report presents a detailed study on the design and analysis of the Piston Head of the Internal Combustion Engine with the Additive manufacturing technique of Laser Powder Bed fusions. The variety of materials for additive manufacturing is discussed and the compatible material AlSi10Mg Alloy was selected for Piston. It also focuses on the various simulations of manufacturing the Piston part by utilizing "Autodesk Netfabb Simulation 2020.1". The residual stresses, hotspots, and, lack of fusion spots from simulation results are discussed and the suitable heat treatment analysis and temperature are studied for relieving the stresses. The microstructure, and strength evolution of the as-built AlSi10Mg part by LPBF, with the "Ansys Software", Piston Materials are compared with AlSi10 Mg**.

Keywords: **Additive manufacturing, powder bed fusion, Internal combustion engine, Piston, Residual stress, von mises stress, Ansys, Simulation**.

I. INTRODUCTION

Additive manufacturing (AM) is the option of material by PC control for assembling in different terms it is alluded to as 3D printing. In traditional assembling, we need to take away the material to acquire the necessary article. Be that as it may, in AM the cycle is altogether unique, where the material is added layer by layer to frame the necessary article. The principal endeavor to make the articles in AM by utilizing photopolymers occurred around the finish of the 1960s in the Battelle Memorial Institute utilizing lasers. Later in 1967 wyn k. Swainson of Denmark applied for a patent named technique for delivering a 3D printed figure by holograph on a double laser which was utilized by the last option. Then Chromatograph substance machining was instituted by Firmographic Engine Co. during the 1970s double laser approach and its most memorable business printing was begun around the same time.

The characterization of added substance fabricating is given underneath.

Fig1.1Types of additive manufacturing

II. HISTORY OF ADDITIVE MANUFACTURING

Improvement of stereo lithography was finished in Japan on the name of the single laser pillar relieving approach by

Hideo Kodama in May 1980 and documented a patent which in the long run got terminated before it was to continue to the assessment size. Later around the same time in October, he distributed a paper on three-layered information shown via programmed readiness of a three-layered work model which illustrated his work top to bottom. He did investigate projecting the UV light by Toshiba mercury light and a photosensitive pitch Tevistar. In a survey of logical examinations, that's what Kodama claims on the off chance that the cemented layer is submerged in the pitch to a profundity of a thickness equivalent to the necessary layer to be hardened then the unsolidified layer of tar goes about as a polymer material.

III. LITERATURE REVIEW

A literature survey was done by gathering papers from the standard journal, and various authors were analyzed in their respective papers.

1.**P Hammed**[1]:**C**oncentrates on the improvement of particular laser liquefied Ti combinations and composites, for the most part, focused on the densification and mechanical way of behaving of the material. Unequivocally restricted bits of knowledge were acquired on their consumption, high-temperature oxidation, and tribological conduct, other than for a couple of well-known frameworks, for example, Ti-6Al-4V and CP-Ti. For high stacking conditions and variable modulus prerequisites, it is indispensable to change the organization, stage development, microstructure, and plan of the Ti combinations. To meet such custom-fitted requirements, SLM has substantiated itself with a strong technique to control the construction and properties of Ti combinations and composites.

2. **Shubhavardhan Ramadurga Narasimharaju[2]** LPBF cycle of metals is acquiring prevalence while showing critical development alongside making more noteworthy strides in novel and trend-setting innovations to make it more aggressive, and financially savvy. LPBF innovation offers new open doors underway ideal models and adaptability of manufacturing complex designs, from different logical and specialized development modern applications to retail and individual items. Because of the higher opportunity of the plan, the LPBF cycle is exceptionally proficient in delivering individual or modified items for the most part in medical services, aviation clinical inserts, cross-section type structures, high-temperature obstruction, and high strength joined with lower-weight enormous parts.

Incredibly fine microstructures inside the covering melt pools. Three districts of grains make up each dissolve pool; the center with fine equiaxed grains, the limit with coarser columnar grains, and the intensity impacted zone. The columnar grains fill toward the warm inclination. This

directionality delivers a finished material with a surface controllable by the output.

3. Dmitry Kotoban [3] **T**he two cycles show the manufacturability of the pre-alloyed Ni3Al nickel aluminide powder. For the single tracks, layers, and multifaceted articles, a few cross-segments were obtained with various calculations and designs. The calculation of the DLMD and SLM tests was like the distinction in the least sizes of track cross-segments (200 μm and 70 μm, respectively). The SLM tests show a smoother side view structure and a less unpleasant surface. Conversely, the DLMD cycle permits late in-flight particles to sinter with the surface. The large-scale porosity was not distinguished for the two cycles, while the examples gave microporosity 0.5… 1 μm sizes. Multifaceted examples have defenselessness to breaking, evidently in the intensity impacted zone as a result of serious areas of strength for the cycle.

The microstructure presents structures that are like marten site for the two cycles. The dendrites were distinguished with the developing heading ordinary and lined up with the filtering bearing. The SLM examples present a better construction as a result of the distinction between the DLMD warm cycle and the cooling rates.

4. **Gunther Mohr** [4]**I**n his review, the significance of ILT and construct level for part quality and properties of L-PBF parts have been featured. Furthermore, examining boundaries coming about in various VED was thought of as Calculation in its most straightforward adjustment, i.e., building level, and ILT can actuate tremendous contrasts to a limited extent quality and its properties. Utilizing the case of a tension vessel, the significance of the picked between layer times.

IV.PISTON COMPONENT & DESIGN

A piston is a cylindrical movable portion of the combustion chamber; the piston is the most fundamental piece of a responding motor; it assists with changing over the substance energy into valuable mechanical Energy. The cylinder gives a method for passing the development of the gasses onto the driving rod, through the interfacing pole. The interfacing pole assists with changing the responding movement into a spinning movement at the driving rod of the engine.

Pistons are typically made of a cast aluminum combination for magnificent and lightweight. (Warm conductivity, is the capacity of a material to direct intensity through it), The cylinder is made sufficiently able to support the accompanying trademark Fluctuating burden and A high temperature of the gasses.

Different types of Piston materials used for manufacturing are Aluminum Alloys Steel alloys like Cast steel and Forged steel, in an engine in which the piston speed is low, it is made of cast iron. The aluminum alloy has good

conductivity, so the -heat dissipation is good and performs better heat transfer.

We have used AlSi10Mg as material to manufacture Piston due to its various properties as a common projecting combination with great projecting properties and is regularly utilized for projected leaves behind slight walls and complex math. It offers great strength, hardness, and dynamic properties and is in this way likewise utilized for parts subject to high loads.

Properties of AlSi10Mg

Density	2.68g/cm^3
Relative Density	>99.5 %
E Modulus	50-70 Gpa
Yield Strength	215-245 Mpa
Thermal conductivity	160 W/m.K
Specific Heat Capacity	860-960 J/(kg K)
Tensile Strength	430-470 Mpa

Chemical Composition of AlSi10Mg Alloy

Al Alloy Element	Al	Si	Cu	Mn	Mg	Zn	Fe
Weight %	Balanced	9-11	<0.05	<0.45	0.2-0.45	<0.10	<0.55

AlSi10Mg comes with a spherical structure of size 20-45 μm which results in layer thickness.

A software platform **AutoCAD** is used for Designing a Piston from 2D to 3D and later it is exported to STL format to simulate the further process.
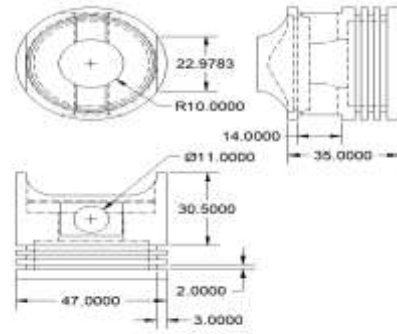
Fig 4.1 Modelling of Piston in AutoCAD
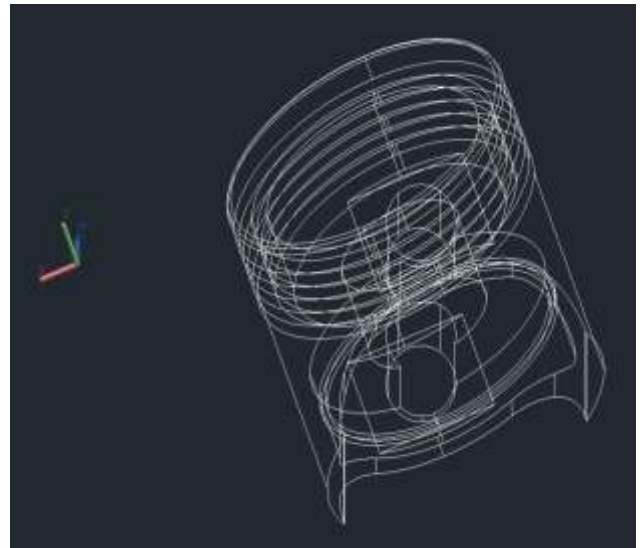
Fig 4.2 Design of 2D wireframe
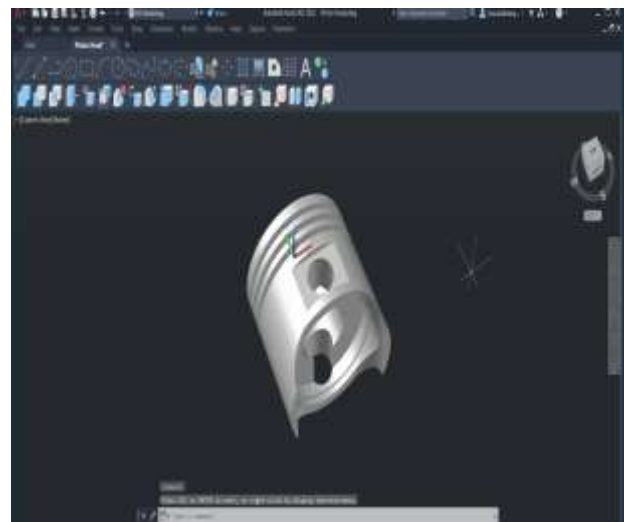
Fig 4.3 Piston Drawing 3D from AutoCad 2022

V. METHODS

MAM is the process of obtaining 3D from cad models by layer by layer adding of material. It is different from conventional machining as it is subtractive machining where the material is removed from the substrate. Besides the removal of material, in AM material is added.

5.1 Powder bed Fusion:

Powder bed combination (LPBF) has a main position selected by aviation, clinical designing, and device fabricating enterprises, this is because of the tremendous expected presented by the cycle's intrinsic level of opportunity in the plan, prompting enhancements in the development of mind-boggling and lightweight designs.

Different part calculations as well as various handling boundaries and examining methodologies, joined by fragmented documentation of a few sections for every form, The outcome is a tremendous scope of distributed values for similar materials. LPBF is dependable and practically identical data about mechanical properties and potential in homogeneities are expected for the plan of wellbeing complex parts.

VI. EXPERIMENT SETUP OF PISTON :

A 3D modeling of the piston is made on Auto Cad Software and made ready.STL format files to as to open in Netfabb Software to perform Additive Manufacturing and Later, Compare the materials in Ansys Simulation Software.

6.1 Description of Equipment used for Simulation

The machine was used to simulate the component Piston in Aconity Mini with building volumes of 140 mmx140mmx200mm. Leading-edge laser sintering system for the manufacture of metal products directly from CAD.

Fig 6.1 Aconity Mini Machine

6.2 Specification of machine:

Aconity mini–Specification Building volume (incl. building platform)	50 mm x 90 mm x 50 mm
Laser	Yb-fiber laser, 250 W
Optics	F-theta-lens with high-speed scanning
Scan speed while build process	max 800 mm/s (23 ft/s)
Focus diameter	150 μm
Power supply	32 A
Power consumption	Maximum 4.5kW
Pressurized air supply	7 000 hPa; 20 m3/h (102 psi; 26 yd3/h

Table 6.2 Aconity Mini Machine Specifications

Autodesk Netfabb 2020.1 Software was used for the part and simulation analysis of the Piston. After modeling the 3D part of the Piston, it is exported into the STL format file. This file is imported into the Netfabb home screen for further process
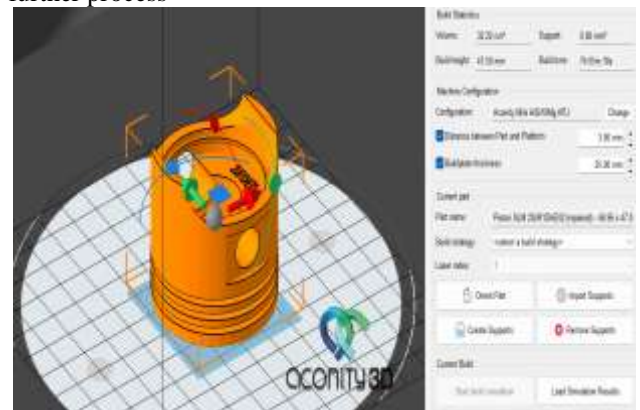

.
Fig 6.3.2 Uploaded to Netfabb

The part is placed in the middle of the build plate and the positions of the orientations are analyzed using the Netfabb orientation analysis setup and the top 12 positions are obtained. The orientation of the part is important because it helps in finding out the time required for the buildup of the part, the amount of powder required for the part, and also for the amount of material needed for the supports. We aim to choose the optimum possible orientation for which the buildup time is minimum along with minimum support structures and least powder usage.

Also, another important thing to consider would be giving the refinish to the part by removing the support structures.
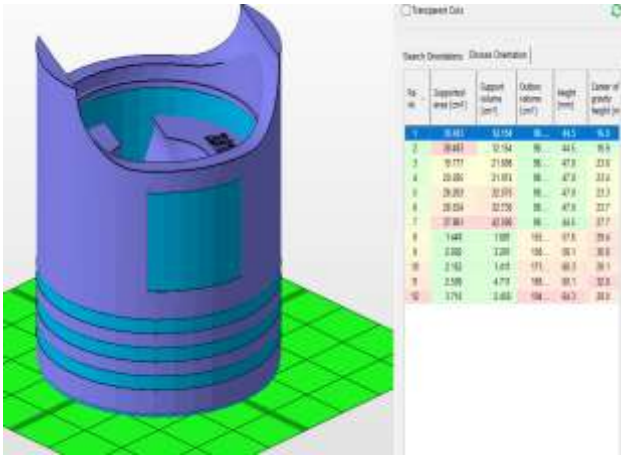

Fig 6.3.3 Orientation analysis result showing the best position

The optimum part orientation helps in effective refining of the finished part removing the support material easily. The best orientation for the given part, obtained in Rank 1 row in Netfabb is to keep the face of the injector part parallel to the vertical plane. The volume of material required for the support structures and the area of the past they support is from the heat generated seen in the table in Figure.
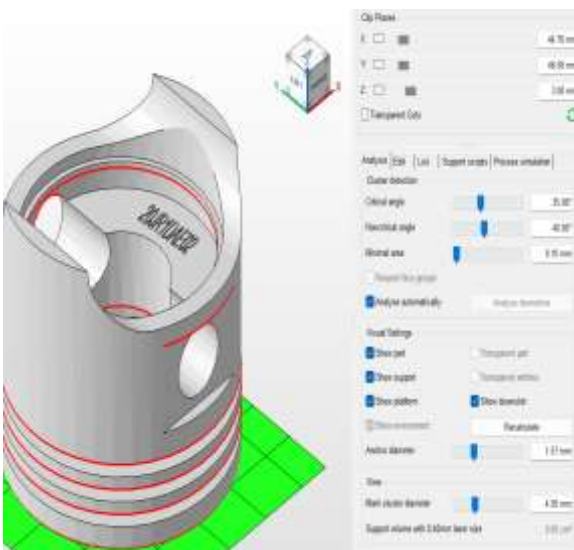
Fig 6.3.4 Highlighted Critical areas are requiring to support

The support structures form important supports for the buildup part while the part is being generated layer by layer as they provide structural strength to the part while it is getting built and also help in effective dissipation of the heat generated. The support structures should be designed

in such a way that it would be easier to remove them from the main part after processing.
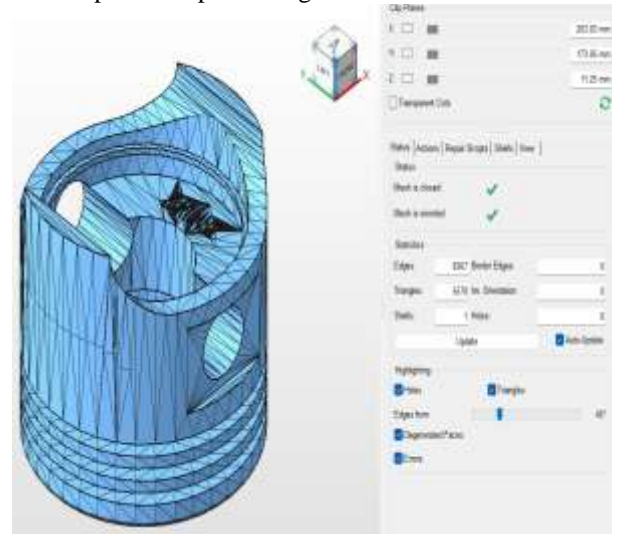
Fig 6.3.5 Creating triangulation to Components

After setting up the part in the best orientation, we move to the generated support section in Netfabb. As the supports section opens, we can see the highlighted red color areas on the part. The cluster detection shows the critical and non-critical sections on the part that require support. The critical sections are highlighted as red areas. These sections can be selected manually to app fully support or we can run the automatic predefined support scripts provided in the Netfabb, the script selected for the part is the standard SLM volume support.
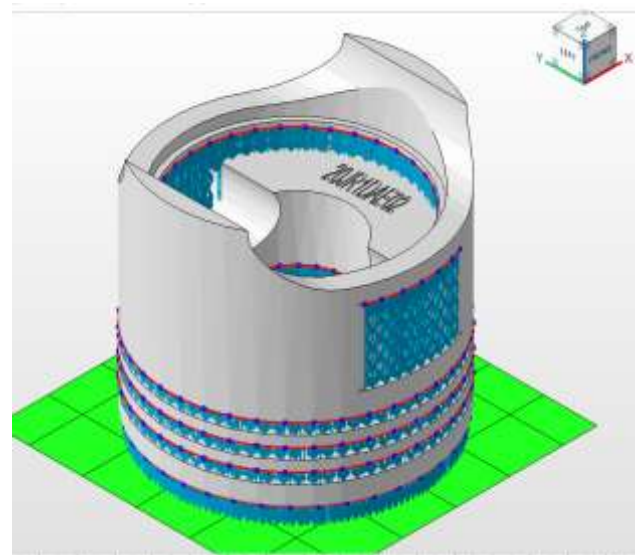

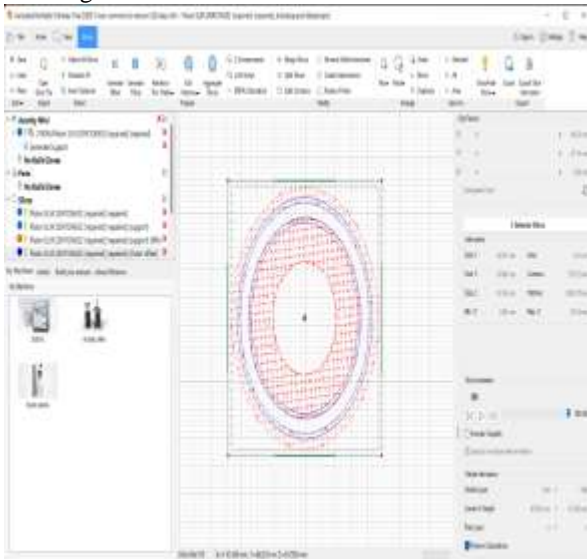Fig 6.3.7 Supports Applied to Weak Areas

6.4 Slicing

Fig 6.4 Slicing using NetFabb before importing for simulation

The software allows to saving of STL (Standard Tessellation Language) file (to keep up with the picked situating), while the produced upholds were saved as a LI Common 63 Layer Interface" file and Slicing data in SLI "Slice Layer Interface" format in the simulations Netfabb Simulation Software.

After importing the STL file into the Netfabb simulation, we need to assign certain measurements to start the simulation. When the STL documents are stacked on Netfabb Simulation, characterizing the interaction parameters is conceivable. Different interaction boundaries were utilized for the part, the backings, and the underlying openness of the structure plate.

Now we fit the part to the build plate size by using the snap to X and Y option in the Build plate settings. For better simulation viewing results we need to modify the build plate sizes in X, Y, and Z Axes and save the information.

The machine comprises a process chamber with a recoating system, elevating system, and a platform heating module.

Now the machine for the simulation is selected as AlSi10Mg as the powder material for the process. The interaction boundaries utilized during the reproductions can't be transformed from the standard ones except if an alternate permit is utilized (Autodesk Netfabb Local Simulation).

The fact of the matter is that with regards to new material, the standard interaction boundaries are not embedded, then, at that point, enter physically. The PRM document (Process Parameters) which ought to be imported is written in a scrambled code. In this manner, it is impossible to complete a reproduction thinking about another material, except if utilizing the drawn-out permit.

A portion of the difficulties in AM reproduction will be won exclusively by running a very enormous number of tests and by tentatively approving the outcomes from the code. What counts is to track down a decent split of the difference between having a point-by-point investigation and restricting the calculation time. Despite software limitations we got, a suitable Processing Parameter file in the software library for our part to run simulations of machines.

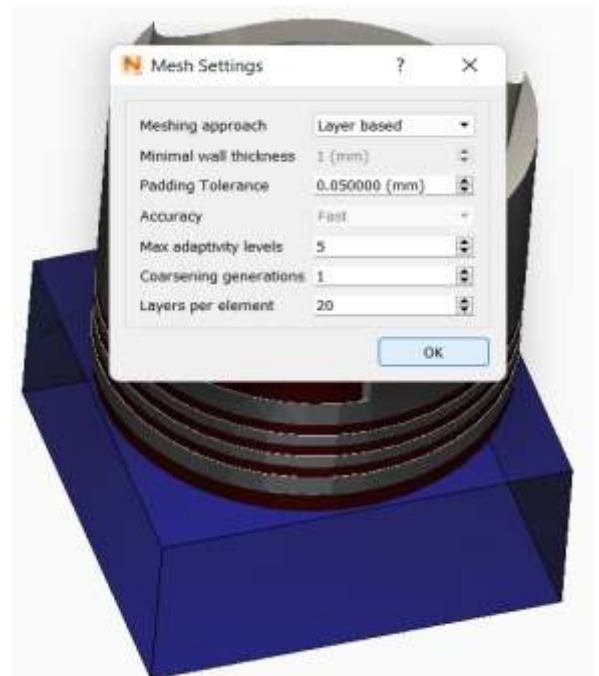Fig 6.5.2 Imported file with pre-positioned data

Fig 6.5.7 Mesh settings considered

Now coming to the meshing part, a 3D cross section is the underlying form of a 3D model comprising polygons. 3D cross-section module is utilized to see in X, Y, and Z., as well as the profundity, width, and length of the part. The polygons utilized, are regularly quadrangles or triangles; these mathematical shapes can be additionally separated into vertices in X, Y, and Z facilitates and lines.

So, to refine the mesh of the model, we go to mesh settings and decrease the layers per element and set it to 20 layers per element to refine the mesh. A further reduction would result in finer mesh but due to limited computation power, this value was selected. The more refined mesh shows a better resolution of the simulation.
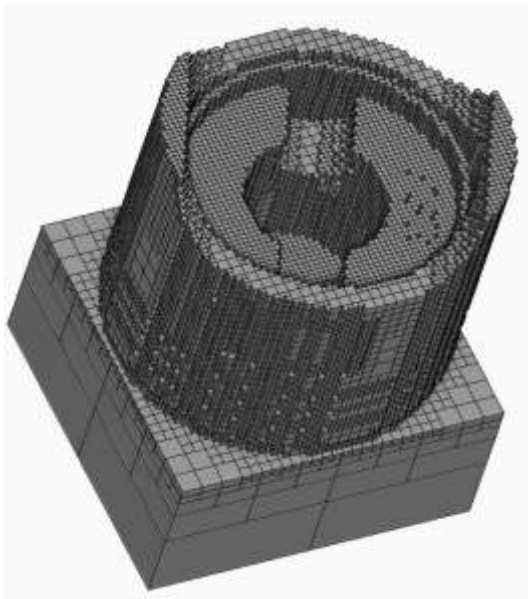
Fig 6.5.8 Mesh results of Piston

Before attempting a full simulation, we need to check the quality of the mesh by clicking Mesh Preview. After this step, we need to start saving the project data to run various Analysis simulations. In the end, we can see the mesh of the component.

VII. RESULTS OF SIMULATION

7.1 Displacement Analysis

From the simulation results in Netfabb, we can see the displacement of the part in various segments in the figure below. Displacement occurs due to distortion of the layers in the material after the successive layer depositions and cooling rates. A maximum of 1.229 mm displacement and a minimum of 2.699 mm have been obtained for the Piston after the deposition process. Shown below figure
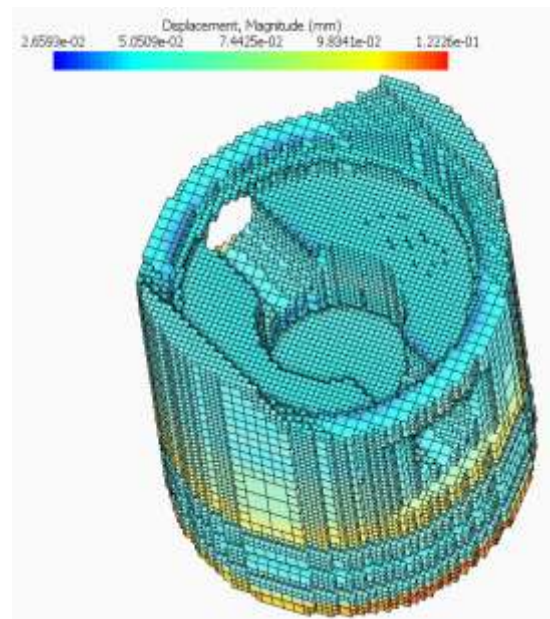

Fig 7.1 Displacement Analysis

7.2 Cauchy Stress:

The Cauchy stress tensor, also called true stress tensor, is a second-order tensor consisting of 9 components that completely explore the state of stress at a point inside the material where the deformation occurs.
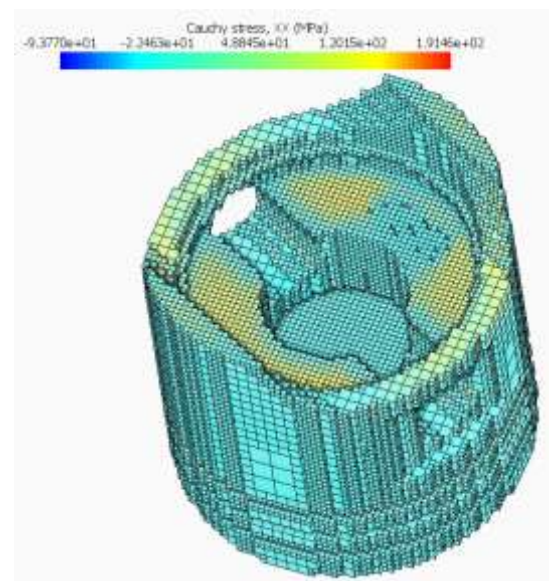

Fig 7.2 Cauchy stress

Cauchy stress is used for stress analysis of material bodies that experience small deformations. The Cauchy stress results obtained after simulation in NetFabb show a positive maximum value of -9.377 Mpa and a negative maximum of 1.914 Mpa.

7.3 Principal Stress

The normal stress on the principal planehas zero shear stress. Maximum principal stress is the maximum of the values of stress acting on the principal plane. In the simulation results shown below, maximum principal stress of -3.426 Mpa has been observed and a negative maximum of 2.502 Mpa.
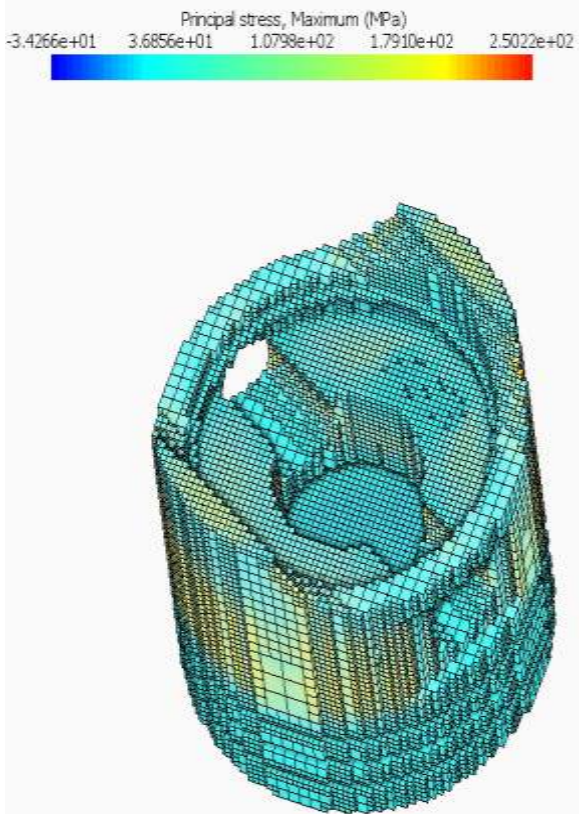

Fig7.3Principle maximum stress

7.4 Detailed Analysis of Piston:

Initially, Part level simulation was done for all components by using default Processing Parameters (PRM) files. But the next analytical simulations are done for PISTON with various Processing Parameters available in software settings. Below mentioned Simulations are helpful to analyze the part in detail:

1) Assign Boundary Conditions & Account for Trapped Powder

2) Predict Residual Stresses and Post Electron Discharge Machining Distortion

3) Analyze Lack of Fusion and Hot Spots

4) Simulating the Stresses of Relief Heat Treatment. Assigning the Boundary Conditions & Account for Trapped Powder

By default, the thermal boundary condition is a static uniform heat flux on the surfaces of the base plate and component. For components that are closely packed together or have hollow walls or similar features where significant heat can be transferred through the powder, the model accuracy will be improved by modeling fine grains of powder. About assigning boundary conditions and accounting for trapped powder analysis the objectives here are to assign thermal & mechanical boundary conditions to the base component. We need to set thermal boundary conditions. We go to the build plate properties tab to review the heating options. Three of them are spotted here.

1) There would be no thermal boundary condition, just start at room temperature and allow the build plate to absorb the heat of the build.

2) **Initial temperature** means assigning a particular temperature at the start of the build but not holding that temperature.

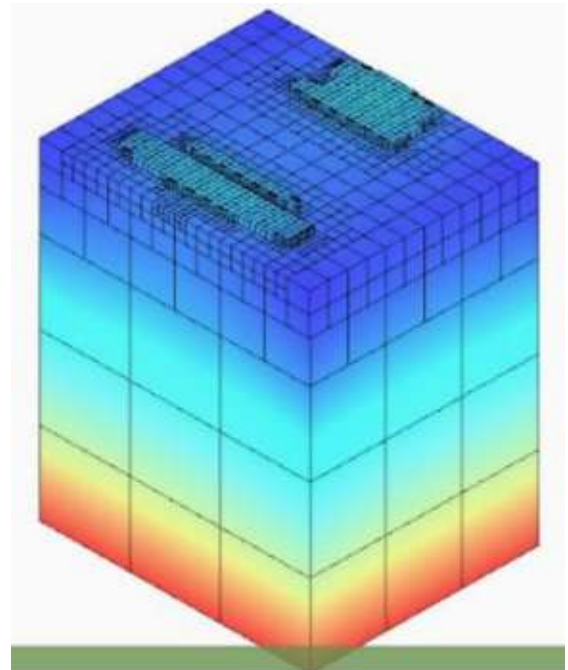3) **Controlled temperature** in which you set a temperature that will be maintained throughout the build process.

Fig 7.4.2 Pre-heated build plate before deposition

In a preheated build plate, the build plate is heated from below to a set temperature of 100 C. As we can see the buildup of the heat of 100 C from the bottom of the build plate before the deposition of the material. As each layer is fused using a laser, the fused previous layers close to the build plate cool down and reach temperatures around 105 – 120 C while the build plate is still maintained at 100 C.
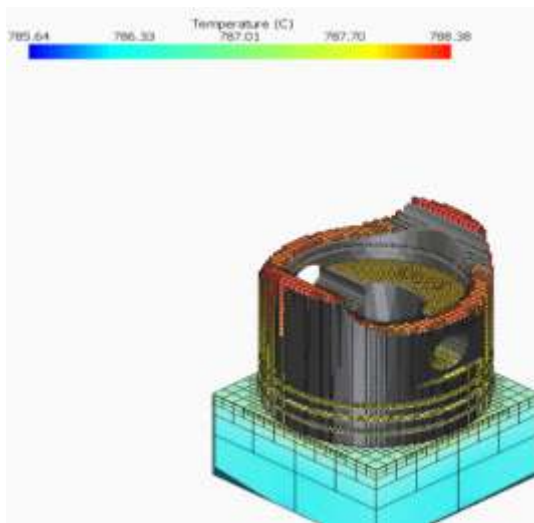
Fig 7.4.3 The plate maintains its initial temperatures while thetop layer gets deposited.

After all the fused layers as in the above figure, we can see the part cooled. The temperature field here is used with the initial temperature or controlled temperature selection then the fixture is a mechanical boundary condition with two options fixed the entire bottom makes all bottom nodes of the part fixed in all degrees of freedom. A controlled temperature of 100 degrees Celsius and a fixture on the bottom of the build plate were selected and put to solve.

This temperature gradient can affect the mechanical response so for greater accuracy, we need to simulate all the loose powder in the analysis. For that operating conditions were set to "conduction to loose powder" as thermal boundary conditions. With this setting, we can simulate the entire loose powder.
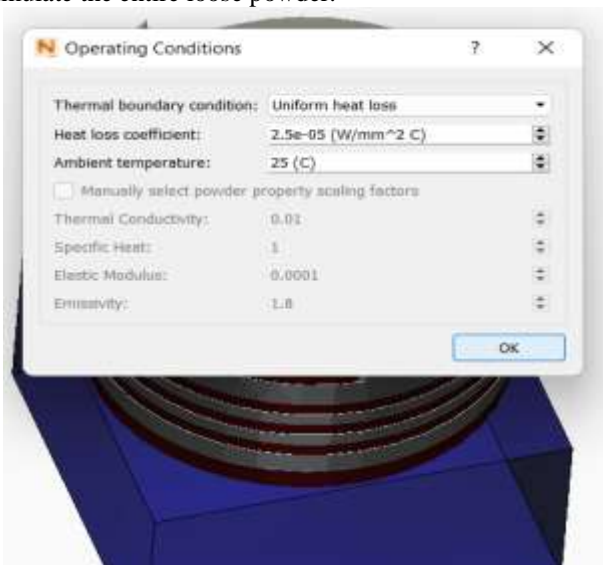
Fig 7.4.4 Adjusting setting to conduction to loose powder

7.5 Predict von mises stress:

The von mises stresses represent the equivalent stress state of the material before the distortional energy reaches its yield point. Note that the von mises stress only considers distortional energy.
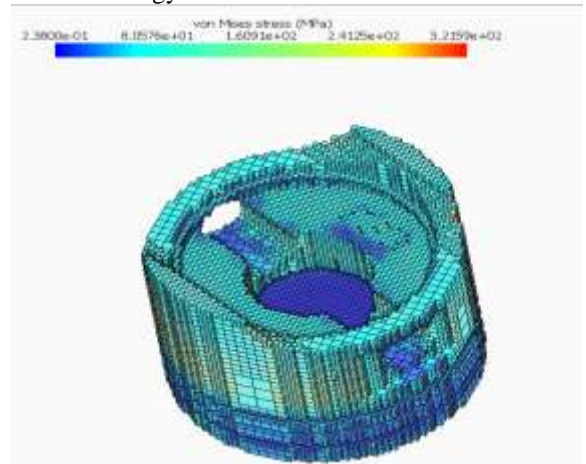

Fig 7.5 von mises stress at the yield point the stress is maximum

7.6 Analysis of Lack of Fusion and Hot Spots

Poor processing conditions will appear at abnormal thermal stress will cause bad quality, less heat will lead to porosity and more heating of the plate causes a hot spot in the base area. Hot spot causes due by overheating of particular weak areas due to high-temperature issues. This tutorial guides users through the process of performing a multi-scale analysis to predict these unwanted phenomena.
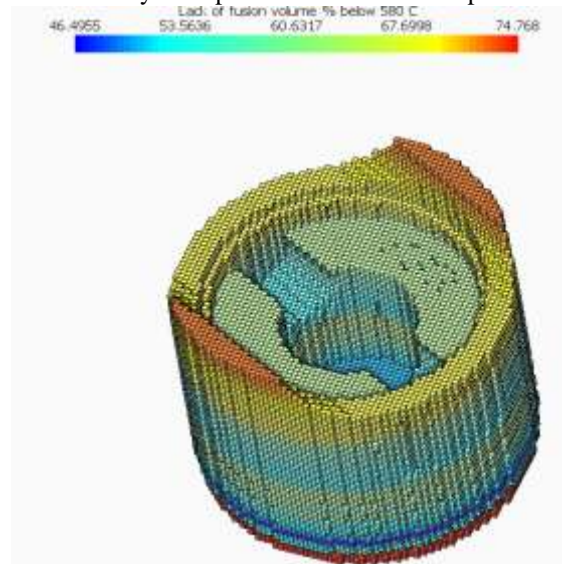

Fig 7.6 lack of fusion volume

7.7 Hot spot temperatures:

This specifies the temperature(s) that, if exceeded, can result in poor build quality. The results of the ensuing part-level simulation depict the percentage of each element likely to be above each hot spot temperature.
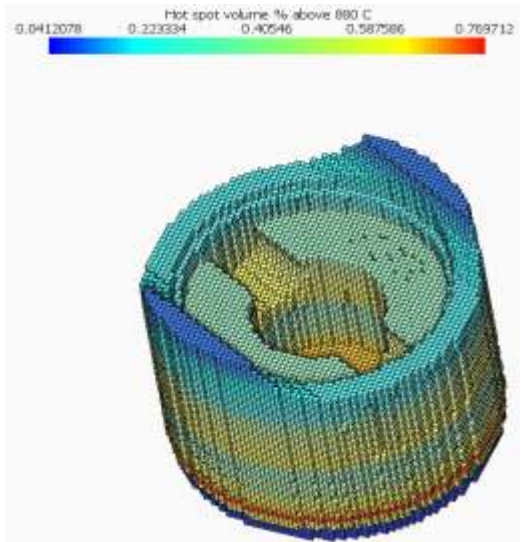

Fig 7.7 Hotspot volume at 880 C

7.8 Interlayer temperatures

Interlayer Temperature is the temperature where the deposited material and build plate after completing a layer, is distributed over the volume and the recoater will come back to its referral point. This is the peak point of the Netfabb sim. It is the primary condition for the simulation for the upcoming layer to solve. More temperatures create a finer level of prediction, but each additional temperature will add computational time shown in the below figure.
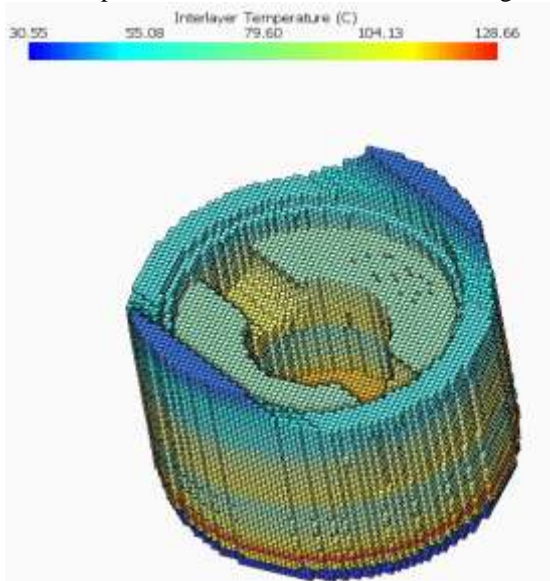
Fig 7.8 Inter-layer temperature

VIII. ANALYSIS OF COMPONENT

8.1 Uploading component file in Ansys Software:

Ansys is a software It creates and advertises CAE/ Multiphysics designing recreation programming for item configuration, testing, and activity and offers its items and administrations to clients around the world.

A numerical analytical method known as the finite element method can be used to provide approximations of solutions to a wide range of engineering issues. It is getting a lot of attention in engineering schools and industry due to its diversity and adaptability as an analytical tool. The need for obtaining approximate answers to issues rather than perfect closed-form solutions is becoming more and more prevalent in engineering scenarios nowadays.

For many engineering problems, analytical mathematical solutions are not feasible. An analytical solution is a mathematical formula that provides the desired unknown quantity's values at any place in the body, making it applicable to an unlimited number of situations. A few spots all through the body. When dealing with issues involving complicated material properties, when dealing with boundary conditions, the engineer turns to numerical techniques that offer rough but acceptable answers.

The finite element approach has developed into a potent instrument for the numerical resolution of a wide variety of engineering problems. It has grown at the same time that the use of high-speed electronic digital computers and the use of numerical methods for engineering analysis have both increased. This approach was developed as a generalization of the structural idea to a few problems involving the elastic continuum that was initially formulated as extremum problems or in terms of other equations.

The step-by-step procedure for the static structural problems can be stated as follows:

Step 1: - Description of Structure (Domain).
The first step in the finite element method is to divide the structure of the solution region into sub-divisions or elements.

Stage 2: - Choice of appropriate insertion model.
Since the relocation (field variable) arrangement of an intricate design under any predefined load conditions can't be anticipated precisely, we expect some reasonable arrangement, inside a component to surmise the obscure arrangement. The expected arrangement should be basic and it ought to fulfill specific union necessities

Step 3: - Derivation of element stiffness matrices (characteristic matrices) and load vectors. From the assumed displacement model, the stiffness matrix [K €] and the load vector P€ of element 'e' are to be derived by using either equilibrium conditions or a suitable Variation principle.

Stage 4: - Gathering of component conditions to acquire the balance conditions. Since the structure is composed of several finite elements, the individual element stiffness matrices and load vectors are to be assembled suitably and the overall equilibrium of the equation has to be formulated as

$[K]\varphi = P$

Where [K] is called assembled stiffness matrix,

Φ is called the vector of nodal displacement and P is the vector or nodal force for the complete structure.

Stage 5: - Arrangement of framework condition to find nodal upsides of relocation (field variable)

The general balance conditions must be altered to represent the limit states of the issue. After the consolidation of the limit conditions, the harmony conditions can be communicated as, $[K]\varphi = P$ For direct issues, the vector 'φ' can be settled without any problem. Be that as it may, for non-straight issues, the arrangement must be gotten in a succession of steps, each step including the change of the solidness grid [K] and 'φ' or the heap vector P.

Stage 6: - Calculation of component strains and stresses.

If the known nodal displacements are required, the element strains and stresses can be computed using the necessary equations of solid or structural mechanics. The words in brackets continue to carry out all the general FEM fulfilling the basic method.

ANSYS can perform Limited Component Examination (FEA) in numerous areas covering numerous applications.

 Underlying Examination: This sort of investigation is the most well-known utilization of FEA and is essentially utilized for mechanical and structural designing applications. The underlying investigation is conceivable in the accompanying regions.

 Static Examination: This kind of examination is utilized to decide the removals and stresses in static stacking conditions.

 Transient Powerful Investigation: This kind of examination is utilized to decide the consonant reaction of construction to time-differing loads.

After mimicking the part in Netfabb, we again take the part to Ansys programming to reenact and concentrate on the pressure created with normally utilized materials and with our AlSi10Mg Material and look at the outcomes, Transferring the 3D part of the cylindrical piston in .iges design, which is a decipherable configuration in Ansys programming, and situating it to a particular position and began fitting the Part
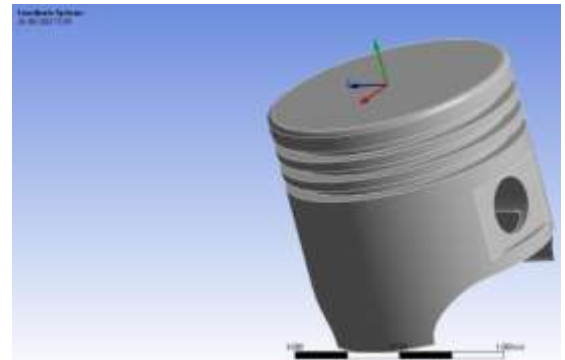

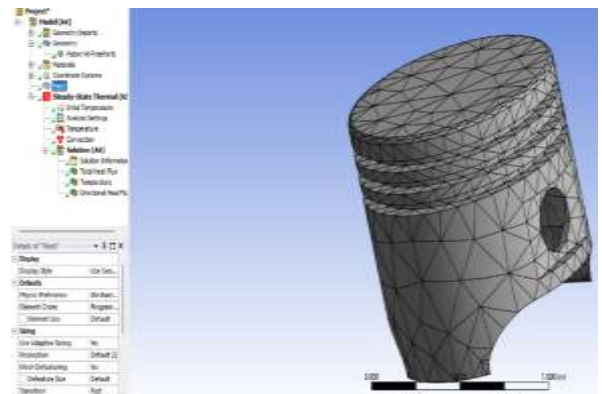Fig 7.1.1 Uploading File in Ansys and orienting it to position

Fig 7.1.2 Meshing of Piston in Ansys Software

8.2 Static Structural Stress:

Static underlying examinations uncover shortcomings in structures Static primary examinations are utilized for straightforward direct estimations as well as complicated material, mathematical, and contact nonlinear computations. The investigation results help to recognize frail regions with low strength and sturdiness. Performing stress analysis with commonly used materials for pistons.

8.2.1 Cast Iron :

Cast Iron is one of the materials used for the piston in specific applications here Ansys of the processes applied to the piston component can be seen in figures from 8.2.1
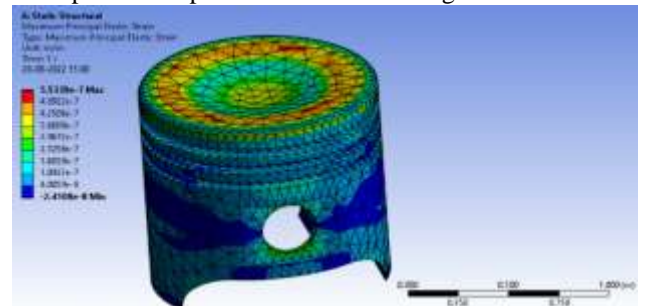

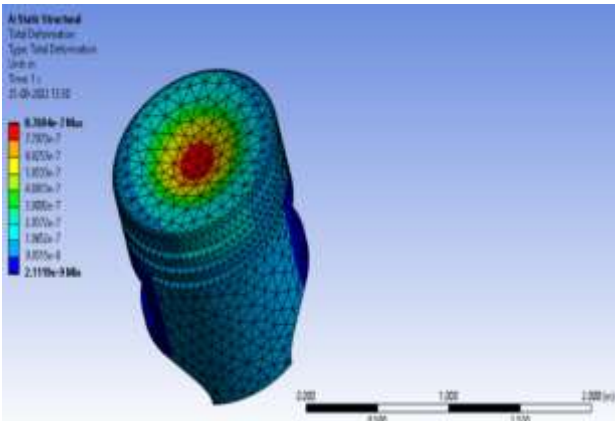Fig 8.2.1(a)Cast Iron under Maximum principal elastic strain

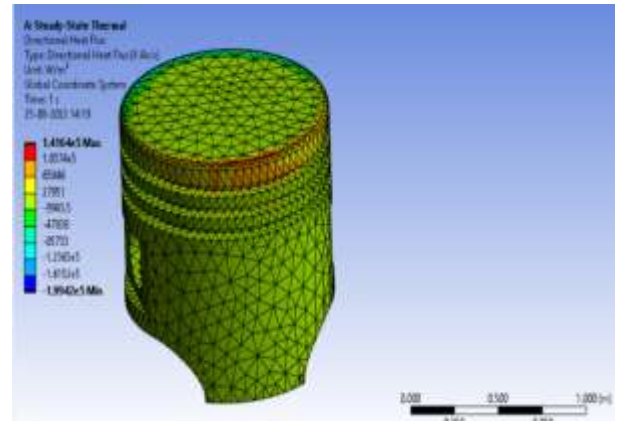Fig 8.2.1 (b) Cast Iron under Total Deformation

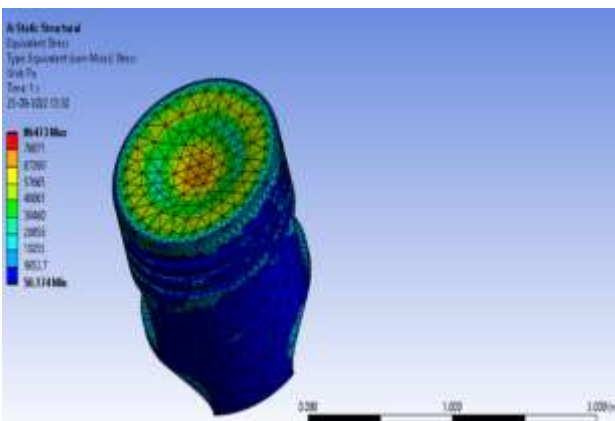Fig 8.2.1 (e) Cast Iron under Directional Heat Flux

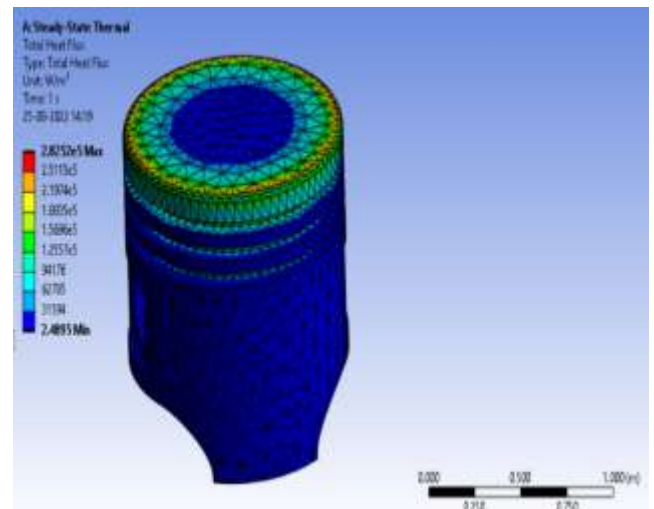Fig 8.2.1 (c) Cast Iron under Equivalent (Von-Mises) Stress
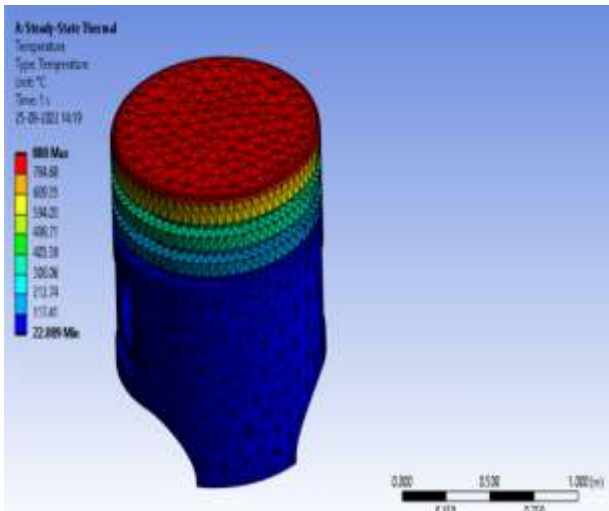

Fig 8.2.1 (f) Cast Iron under Total Heat Flux

8.2.2 Aluminium Alloy:
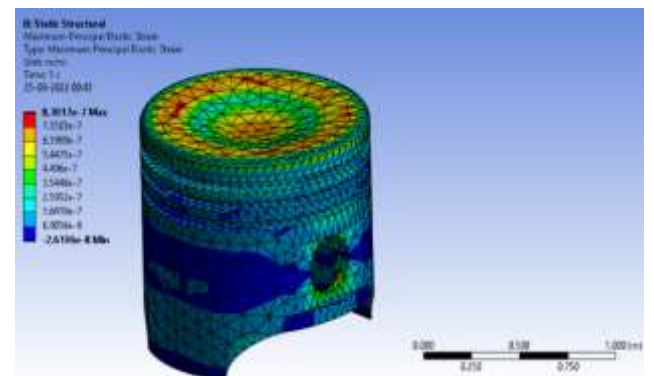Aluminium Alloy is the most common of the materials used for the piston in specific applications where Ansys of the processes applied to the piston component can be seen in figures from 8.2.2
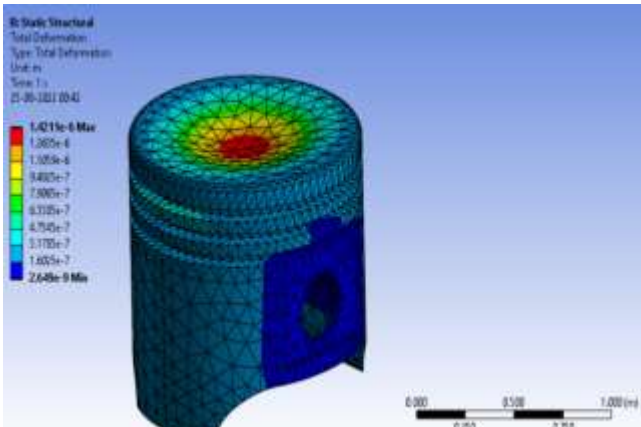

Fig 8.2.1 (d) Cast Iron under Temperature

Fig 8.2.2 (a) Al Alloy under Maximum Principal Elastic Strain

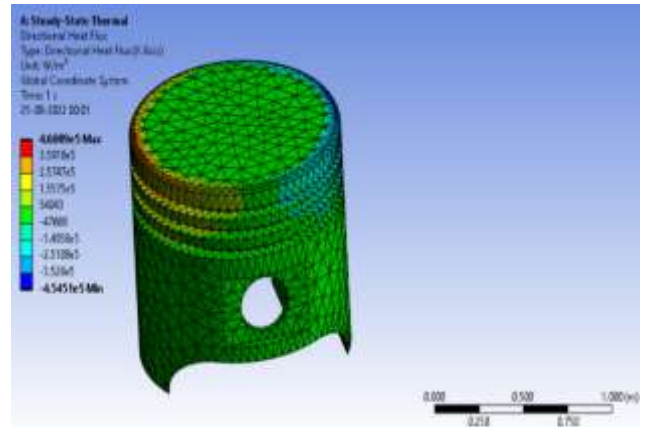Fig 8.2.2 (b) Al Alloy Total Deformation
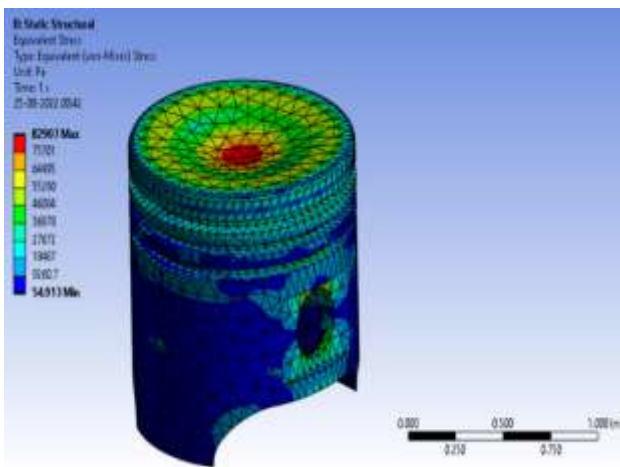

Fig 8.2.2 (e) Al Alloy under Directional Heat Flux

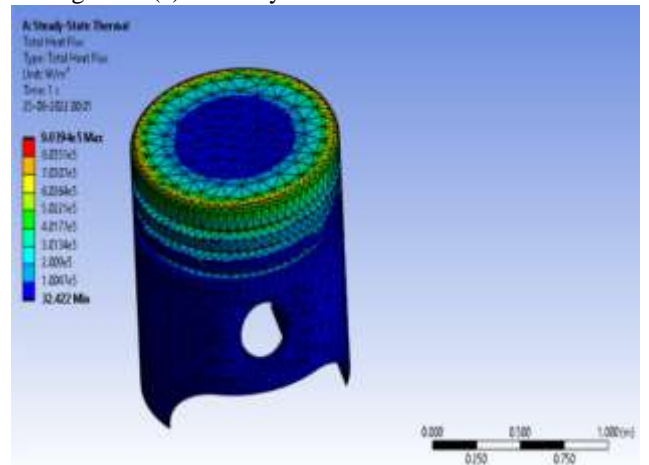Fig 8.2.2 (c) Al Alloy under Equivalent (Von-Mises) Stress

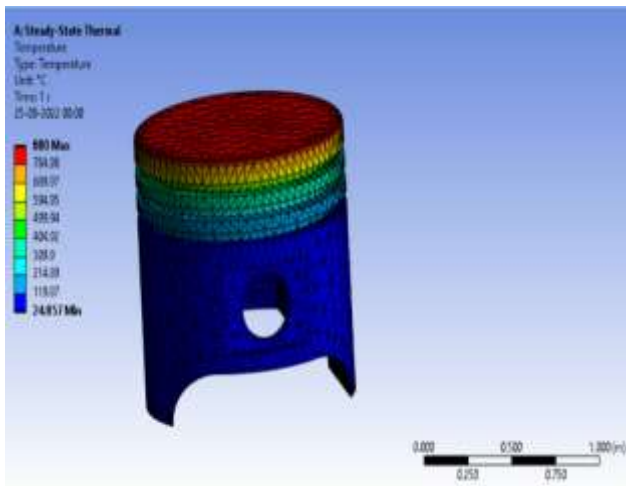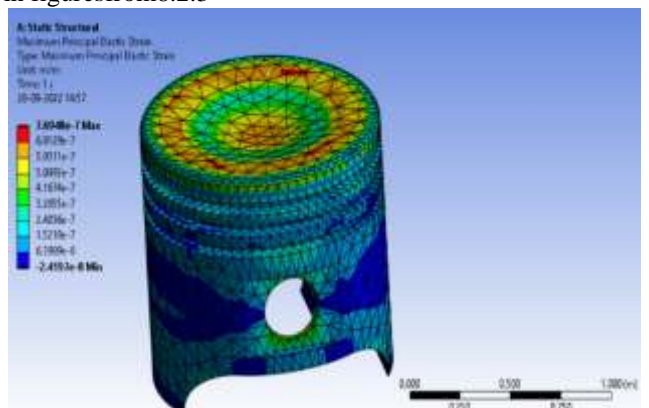Fig 8.2.2 (f) Al Alloy under Total Heat Flux

8.2.3 AlSi10Mg Alloy:

AlSi10Mg Alloy is the most common of the materials used for the piston & prepared by additive manufacturing process, used in specific applications where the Ansys of the processes applied to the piston component can be seen in figuresfrom8.2.3
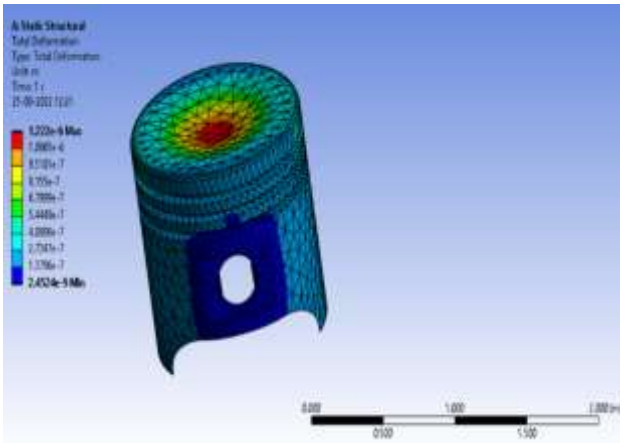

Fig 8.2.2 (d) Al Alloy under Temperature

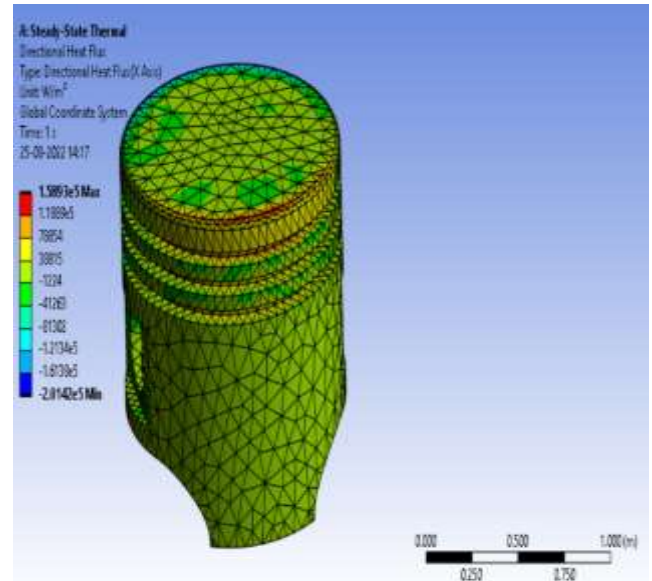Fig 8.2.3 (a) AlSi10Mg Alloy under Maximum Principal Elastic Strain
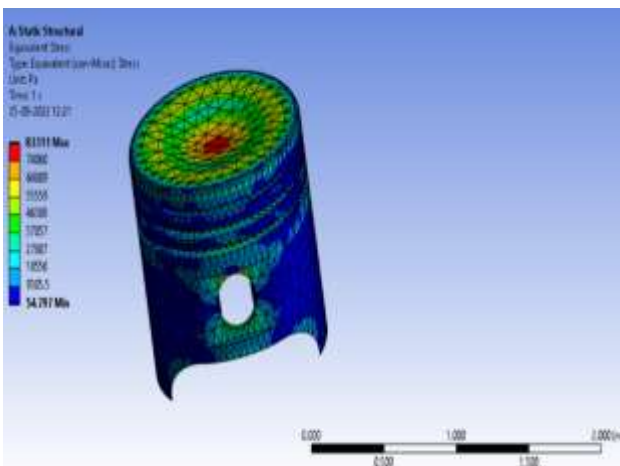
Fig 8.2.3 (b) AlSi10Mg Alloy Total Deformation

Fig 8.2.3 (c) AlSi10Mg Alloy under Equivalent (Von-Mises) Stress

Fig 8.2.3 (d) AlSi10Mg Alloy under Temperature

Fig 8.2.3 (e) AlSi10Mg Alloy under Directional Heat Flux

Fig 8.2.3 (f) AlSi10Mg Alloy under Total Heat Flux

A study on different materials like Cast Iron, Aluminum Alloy, Steel Alloy, and Alsi10Mg Alloy is tested out under Stress, Deformation, and Temperature carried out, and results were obtained with the help of Ansys software.

IX. CONCLUSION & RESULTS

We have used Aconity Machine under Netfabb Software to simulate the component by a process of Additive Manufacturing, the results obtained by NetFabb Simulation are listed below in a tabular column.

Machine: **Aconity Mini** Units

Dimensions	140 x 140 x 200	Mm
Laser	250	W
Build plate support	40 x 90 x 40	Mm
Layer deposition height	0.480	Mm
Cauchy stress Displacement maximum	1.9146e+02	Mpa
Cauchy Stress Displacement minimum	-9.3770E+01	Mpa
Maximum positive stress	1511	Mpa
Minimum negative stress	-1711.8	Mpa
Trapped powder temperature Maximum	70.2	Degree Celsius
Trapped powder temperature Minimum	28.14	Degree Celsius
Hot spot volume Maximum	0.76971	%
Hot spot volume Minimum	0.04120	%
Lack of fusion below 580 C	No Lack of Fusion spots observed	
Heat Treatment Temperature	899	Degree Celsius

Table 9.1 Parameters of Aconity Mini Machine

The previous conversation has endeavored to investigate every one of the means which prompted the total plan reproduction of a Piston for Additive Manufacturing. The goal set was to Simulate a utilitarian part, having equivalent execution and unwavering quality to the current one, yet additionally lighter than that.

The fundamental instrument, important to achieve this undertaking, was running various Simulations. Albeit this reproduction technique was a subject of study for quite a while, it in the long run acquired plausibility because of Additive Manufacturing, by conquering manufacturability restrictions, which are currently allowed by this innovation.

In this Thesis report, microstructures, and tensile and fatigue properties of SLM-built AlSi10Mg component (Piston) are studied and we compare the material with commonly used materials for the pistons to analyze the best of Additive Manufacturing or Conventional Manufacturing of Piston.

Ansys :
A study was carried out by comparing the materials and stresses the results are listed in a tabular column.

Conclusion & Result:
We conclude from the above result that AlSi10Mg material is closer to Aluminum Alloy same stress are seen in above results and AlSi10Mg material is found to fine grain size results good and quick solidification and Si allows the material to be crack free and corrosion resistance, good mach inability properties, and less deformation to Al Alloy with the good thermal distribution.

Table 9.1.2 Stress & Temperature variations among different materials

S.No.	Materials for Piston	Max. Principal Elastic Strain		Total Deformation (m)		Equivalent (Von-Mises) Stress (N/m²)		Temperature (°C)		Directional Heat Flux (W/m²)		Total Heat Flux (W/m²)	
		Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	Cast Iron (CM)	564752	-32358	$8.7694e^{-7}$	$2.1119e^{-9}$	86473	50.174	880	22.089	$1.4164e^{5}$	$-1.9942e^{5}$	$2.8252e^{5}$	2.4895
2	Al Alloy (CM)	$8.3017e^{-7}$	$-2.6106e^{-8}$	$1.4211e^{-6}$	$2.649e^{-9}$	82907	54.913	880	24.857	$4.6089e^{5}$	$-4.5451e^{5}$	$9.0394e^{5}$	32.422
4	AlSi10Mg (AM)	78998	-42032	$1.222e^{-6}$	$2.4524e^{-9}$	83311	54.797	880	23.292	$1.589e^{5}$	$-2.0142e^{5}$	$3.6781e^{5}$	12.898

9.2 Advantages of Additive Manufacturing for Piston Component:

- Making the piston body partially through an additive manufacturing process provides several advantages as compared to conventional manufacturing. Some complex issue seen in conventional manufacturing is made easier in additive manufacturing.
- Material wastage is drastically low in Additive Manufacturing and the strength of the component is good enough compared to conventional manufacturing.

9.3 Future Scope

Added substance fabricating: joint undertaking with Porsche and Trump fyields universes. The principal 3D printed piston.

- Effective testing in Porsche 911 GT2 RS: 200-hour perseverance test on the test seat under the hardest circumstances.
- 3D printed piston expands the presentation and effectiveness of the 700 HP drive unit.
- MAHLE is additionally explicitly fostering its aptitude in 3D printing for application in the field of additive manufacturing.

X. REFERENCES

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