DESIGN AND ANALYSIS OF PISTON WITH COMPOSITE MATERIALS FOR AUTOMOTIVE APPLICATIONS

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Abstract : conversation system, piston plays a very important role. Piston endures the cyclic pressure and therefore the mechanical phenomenon forces at work and this operating condition could cause the fatigue injury of piston like piston facet wear, piston head cracks. Piston failure takes place as a result of mechanical and thermal stresses. Compared to alternative components of IC engine, the piston works on terribly high thermal conditions and is that the foremost stressed part of the engine. the most objective is comparative study of pistons created from completely different materials by victimisation Finite part technique (FEM) and confirm the utmost mechanical and thermal stress ,fatigue strength functioning on the piston by making an attempt structural and transient thermal analysis. Here the period of the piston improves by suggests that of introducing a replacement composite matrix like atomic number 13 alloy with particulates of inorganic compound that has the utmost wear issue. The parameters used for the solid modeling and simulation ar operative pressure , temperature and material properties of piston. The specifications used for the study of those pistons belong to four stroke single cylinder engine of Bajaj neutron star 220 cc For solid modeling we tend to ar victimisation CATIA ,for meshing hyper mesh and ansys 18.0 use as a convergent thinker.

Materials propose: atomic number 13 alloy, Magnesium alloy and atomic number 22 alloy.
Investigations: mechanical and thermal stress, fatigue strength, Model analysis and weight
Bajaj neutron star four stroke 220 cc hydrocarbon engine. Input parameters for piston design
Bore (D) : 67 mm Stroke (L) : 62.4 mm Length of connecting rod: 124.8 mm
Displacement volume : 220 cm3 Compression ratio: 9.5+/-0.5:1 Maximum power: 15.51 kW at 8500 rpm
Maximum torque (T): 19.12 N-m at 7000 rpm (N)

Key words: piston, fatigue analysis, thermal analysis, material , hyper mesh

I.INTRODUCTION

A piston could be a part of mutual engines, mutual pumps, gas compressors, hydraulic cylinders and gas cylinders, among alternative similar mechanisms. it's the moving part that's contained by a cylinder and is formed airtight by piston rings. In associate engine, its purpose is to transfer force from increasing gas within the cylinder to the shaft via a connecting rod and/or rod. In a pump, the operate is reversed and force is transferred from the shaft to the piston for the aim of press or ejecting the fluid within the cylinder. In some engines, the piston additionally acts as a valve by covering and uncovering ports within the cylinder.

Problem Description:

In this paper the strain distribution is evaluated on the four stroke engine piston by victimisation FEA. The finite part analysis is performed by victimisation FEA computer code. The couple field analysis is dole out to calculate stresses and deflection because of thermal hundreds and force per unit area. The materials utilized in this project ar atomic number 13 alloy and ,magnesium alloy and atomic number 22 alloy stuff. during this project the natural frequency and Vibration mode of the piston were additionally obtained and its vibration characteristics ar analyzed. With victimisation pc power-assisted style (CAD), UNI-GRAPHICS computer code the structural model of a piston are going to be developed. what is more, the finite part analysis performed with victimisation computer code ANSYS.

Functions of the Piston:

1.To receive the thrust from the explosion and transmit the force to the shaft through’ rod.
2.To act as a seal in order that the high combustion pressure doesn't escape to the housing.
3.To function a guide and an impact for the rod tiny finish.

Components of Piston: The main parts of the piston ar as follows:
1. Piston Crown 2.Skirt 3.Piston Pin 4.Piston Rings

Types of Pistons: There ar 3 styles of pistons, every named for its shape:.
Flat-top Pistons Dish Pistons Dome Pistons.

II. LITERATURE REVIEW

Ch.Venkata Rajan within the time of 2013 [1]. they have contemplated a cylinder from an inexpensive model that has been thought-about within the blessing operate as a base model. some work has been done on the transcription streamlining with clear cylinders still as cylinders with limit covering as these days. Ajay Beam Singh et al. [2] printed the strain circulation and heat anxieties of three altogether distinctive nuclear variety 13|metal} compound cylinders by abuse restricted part procedure within the time of 2014. dictator Zhao [3] offered associate underlying investigation of the cylinder in 2012. He cleft the cylinder by confirmative of E programming bundle to assist and upgrade the look of the cylinder. Aditya Kumar Gupta et al. [4] examined the cylinder, that were includes of two stages. They were transcription and Examination. S.Srikanth Reddy et al. [5] in 2013 researched the nice and cozy examinations on a norm (uncoated) diesel cylinder. In 2012 Yaochen Xu et al. [6] skint down a cylinder by ANASYS programming to initiate the twisting, heat and stress dispersion of the cylinder. S. Bhattacharya et al. [7] broken away at a cylinder of a two-stroke flash begin burning motor that had most force of half-dozen.5 kW at five00 kindle. They were transcription and Examination. They utilised atomic number 13 4032 amalgam on the grounds that the cylinder material. Dr. L.N. Wan hade et al. [8] calculable the strain and temperature circulation on the foremost elevated surface of a cylinder. the first model of the cylinder would be created abuse CATIA V5 programming bundle. At that time they unknown the pc power-assisted style model into the Hyper Cross section for pure mathematics improvement and lattice reason. Amit B. Solankiet al. [9] delineated vogue investigation and streamlining of [*fr1] breed Cylinder for four stroke single chamber 10 unit (7.35 kW) diesel. They utilised high strength made steel for cylinder crown and light-weight amalgam like atomic number 13 composite for cylinder divider. abuse FEM they examined the strain appropriation of cylinder and investigated the precise motor condition in the course of burning technique. to remain removed from the frustration of the cylinder, the burdens on account of ignition were pondered. SasiKiran Prabhala et al. [10] supplanted the steel leaves behind atomic number 13 components to cut back the heap. The strength of atomic number 13 components wasn't decent contrasted with steel segments. Consequently, they were taking the atomic number 13 combination as a result of the atomic number 13 amalgam displays the strength greatly just like the steel.

III.DESIGN CALCULATIONS OF DRIVE SHAFT

IP = indicated power produced inside the cylinder η = mechanical efficiency= 0.8 L = length of stroke, mm
n = number of working stroke per minute = N/2 N = engine speed A = cross-section area of cylinder, mm^2
l_c = Length of connecting rod, mm a = acceleration of the reciprocating part, m/s^2 m_p = mass of the piston,Kg
V = volume of the piston, mm^3 t_h = thickness of piston head (mm) D = cylinder bore, mm
r = crank radius, mm p_{max} = maximum gas pressure/explosion pressure, MPA σ_t = allowable tensile strength, MPA
σ_{ut} = ultimate tensile strength, MPA FOS = factor of safety= 2.25 K = thermal conductivity/mK
T_c = temperature at the centre of the piston head, K T_e = temperature at the centre of the piston head, K
HCV = Higher Calorific Value of fuel = 47000 KJ/kg BP = brake power of the engine per cylinder, KW
m = mass of fuel used per brake power per second, Kg/Kws
C = ratio of heat absorbed by the piston to the total heat developed in the cylinder is 0.05
P_w = allowable radial pressure on cylinder wall =0.025N/mm^2 σ_p = permissible tensile strength for ring material = 110N/mm^2
h = axial thickness of piston ring, mm h_1= width of top land, mm h_2= width of ring land, mm
t_1 = thickness of piston barrel at the top end, mm t_2 = thickness of piston barrel at open end, mm
l_s = length of skirt, mm μ coefficient of friction = 0.01 l_1 = length of piston pin in the connecting rod bush, mm
d_o = outer dia of piston pin, mm

Mechanical efficiency of the engine (η) = 0.**8** $\boldsymbol{\eta = \frac{B.P}{I.P}}$ $\boldsymbol{B.P = \frac{2\pi NT}{60}}$ = 14.015KW

Therefore, $IP = \frac{BP}{\eta}$ = 14.015/0.8 = 17.518 KW, Also, $IP = P.A.L.N/2$

$17.518 * 1000 = P * \frac{\pi}{4} * 0.067^2 * 0.0624 * 7000$ = 1.137MPA Max.pressure (p_m) = 10*1.137 = 11.37MPA

According to **Grashaff's formula**, thickness of piston is given by $\boldsymbol{t_h = D.\sqrt{\frac{3p_{max}}{16\sigma_t}}}$ Where $\sigma_t = 220MPA$ D = 67mm

Pmax = 11.375MPA t_h = 6.595mm By using Empirical formula, t_h = 0.032D + 1.5 t_h = 3.644mm

On the basis of Heat dissipation, the thickness of piston head is given by, $\boldsymbol{t_h = \frac{[C*HCV*m*BP]*10^6}{12.56*K*(t_c-t_e)*3600}}$

Where, C = ratio of heat absorbed by piston to the total heat developed in the cylinder = 0.05
HCV = Higher calorific Value of fuel = 47000 KJ/Kg, m = mas of fuel used per brake power per second = 28*10^{-3} Kg/kws
K = Thermal Conductivity (W/mK) = 180 W/Mk $t_c - t_e$ = 75°C or 333.15 K for AL based alloys
Substitute the parameters in above equation, t_h = 3.45mm
Comparing the above values for maximum piston head thickness is 6.59mm So, **t_h = 6.595mm**

Piston Rings: The radial width of the ring is given by $\boldsymbol{b = D.\sqrt{\frac{3\, p_w}{\sigma_p}}}$ Where, p_w = 0.025 N/mm^2 σ_p= 110MPA

Substitute the parameters in above equation, **b = 1.7494mm**

Axial Thickness of Piston rings: $\boldsymbol{h = 0.7b + b}$ = 1.2243mm

Width of the top land: $\boldsymbol{h_1 = t_h + 1.2t_h}$ = 7.8mm

Width of the ring land: $\boldsymbol{h_2 = 0.75h \, to \, h}$ = 0.9182mm

Piston Barrel:

Thickness of piston barrel at the top end: $\boldsymbol{t_1 = 0.03D + b + 4.9}$ = 8.6594mm
Thickness of piston barrel at the open end: $\boldsymbol{t_2 = 0.3t_1 \, to \, 0.35t_1}$ = 2.59mm

Length of skirt: $\boldsymbol{l_s = 0.6D \, to \, 0.8D}$ = 40.2mm

Length of piston pin at connecting rod bush: $\boldsymbol{L_l = 0.45 \, of \, Pistondia}$ = 30.15mm

Piston pin diameter: $\boldsymbol{d_o = 0.28D \, to \, 0.38D}$ = 18.76mm

Centre of piston pin should be 0.02D to 0.04d above the centre of skirt.

IV.COMPOSITE MATERIALS

Composite encompass 2 or a lot of material part that ar mix to supply a cloth that has superior properties to those of its individual constituent. Innovatively the most composite ar those wherever the scattered stage is as fiber. The composite materials will be sorted supported miniature styles, multi stages, fortifications, means of pressing of filaments superimposed structures, technique for organizations, grid framework, handling methods, so forth Composite materials will be classified as:

1.Polymer Matrix Composites. 2.Metal Matrix Composites. 3.Ceramic Composites.

Aluminium alloy: Aluminium alloys (or atomic number 13 alloys; see orthography differences) ar alloys within which atomic number 13 (Al) is that the predominant metal. the everyday alloying parts ar copper, magnesium, manganese, silicon, tin and metallic element. There ar 2 head characterizations, specifically jutting compounds and designed amalgams, the 2 of that ar to boot partitioned off into the classifications heat-treatable and non-heat-treatable.

Material Properties of Metal Alloy

Density: 2770 Kg m^-3 Young's Modulus: 71000 MPa Poisson's Ratio: 0.33
Tensile Yield Strength: 280 MPa Compressive Yield Strength: 280 MPa Tensile Ultimate Strength: 310 MPa
Bulk Modulus : 69608 MPa Shear Modulus: 26692 MPa Coefficient of Thermal Expansion: 2.3E-05C^-1
Thermal conductivity: 175@21TWm^-1C^-1 Specific heat: 875 J kg^-1 C^-1

Magnesium Alloy: Magnesium alloys square measure mixtures of atomic number 12 with different metals (called associate alloy), usually Al, zinc, manganese, silicon, copper, rare earths and atomic number 40. atomic number 12 is that the lightest structural metal . atomic number 12 combos have a hexangular grid structure, that influences the crucial properties of those compounds.

Material properties of Magnesium Alloy:

Density: 1800 Kg m^-3 Young's Modulus: 45000 MPa Poisson's Ratio: 0.35
Tensile Yield Strength: 193 MPa Compressive Yield Strength: 193 MPa Tensile Ultimate Strength: 255 MPa
Bulk Modulus : 50000 MPa Shear Modulus: 16667 MPa Coefficient of Thermal Expansion: 2.6E-05C^-1
Thermal conductivity: 156@21TWm^-1C^-1 Specific heat: 1024 J kg^-1 C^-1

Titanium alloy: Titanium alloys square measure alloys that contain a mix of metal and different chemical parts . Such combos have exceptionally high physical property and strength (even at outrageous temperatures). they're lightweight in weight, have new consumption opposition and also the capability to resist outrageous temperatures

Material properties of Titanium Alloy:

Density: 4620 Kg m^-3 Young's Modulus: 96000 MPa Poisson's Ratio: 0.36
Tensile Yield Strength: 930 MPa Compressive Yield Strength: 930 MPa Tensile Ultimate Strength: 1070 MPa
Bulk Modulus : 114285.71 MPa Shear Modulus: 35294 MPa Coefficient of Thermal Expansion: 9.4E-05C^-1
Thermal conductivity: 21.9@21TWm^-1C^-1 Specific heat: 522 J kg^-1 C^-1

V.DESIGN OF THE PISTON

Design software(CATIA): CATIA-Computer motor-assisted 3 Dimensional Interactive Application could be a 3D Product Lifecycle Management software package suite developed by French Company Dassault Systems. CATIA Facilitates cooperative engineering across disciplines with its 3D expertise platform. CATIA permits the user to make elements in high productive and intuitive atmosphere. CATIA enriches exciting product style with basic half and surface style tools; simply established assembly constraints, mechanically positions elements and check assembly consistency.

Feature based mostly Modelling Hybrid Modelling Affiliated Interface
Parametric Plan Wireframe and Surface Design Sheet Metal Design

DESIGN OF THE PISTON

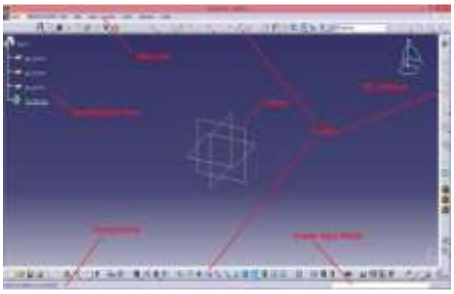


Fig 5.1: CATIA User Interface

Fig 5.2: Command being selected from Menu bar

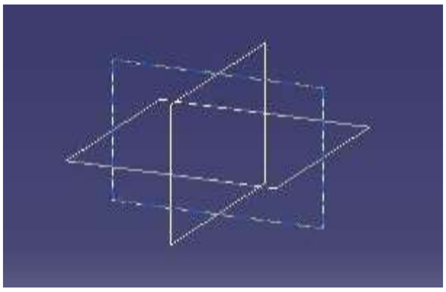


Fig 5.3: Plane being selected

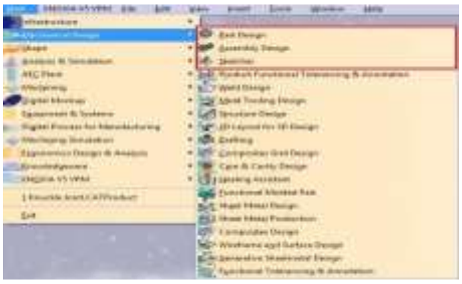


Fig 5.4: Work bench being selected

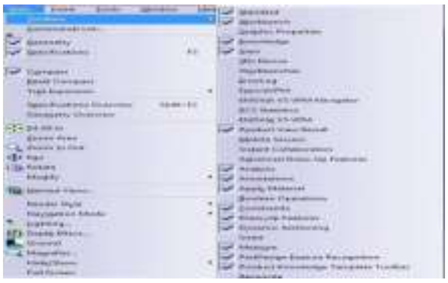


Fig 5.5: Toolbar Listed

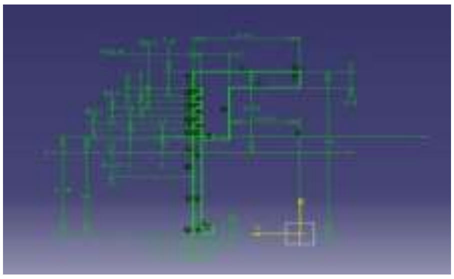


Fig 5.6: Profile of the Piston

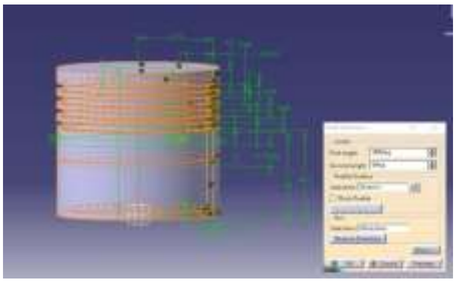


Fig 5.7: Shaft operation to profile of Piston

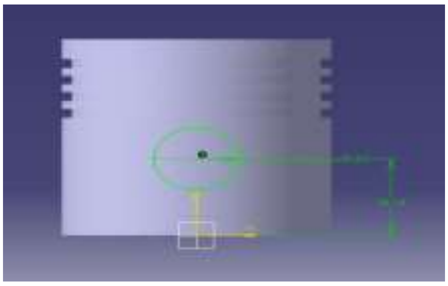


Fig 5.8: Pin Profile of the Piston

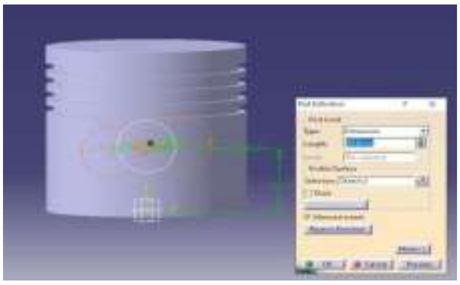


Fig 5.9: Pin profile of the Piston

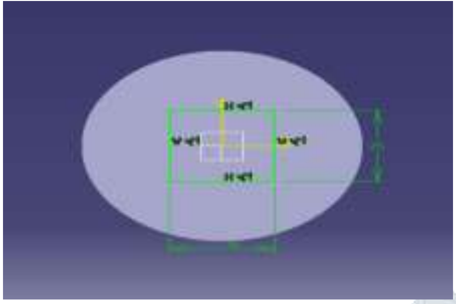


Fig 5.10: lower phase of the Piston

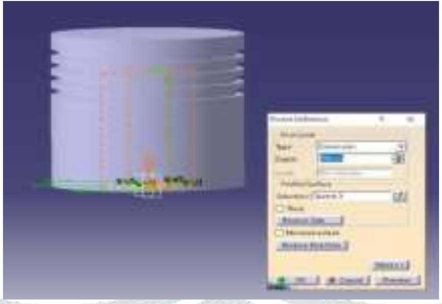


Fig 5.11: Pocket of lower profile of the Piston

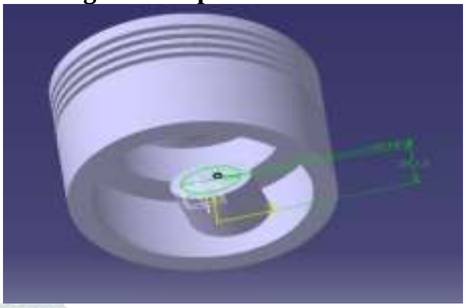


Fig 5.12: Profile on the Pin of the Piston

Fig 5.13: Pocket operation on the Pin

Fig 5.14: Mirror operation of Pocket Pin

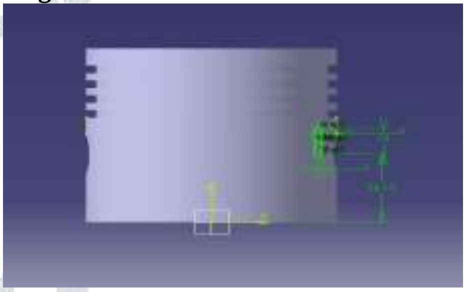


Fig 5.15: Profile for the Groove at the Pin

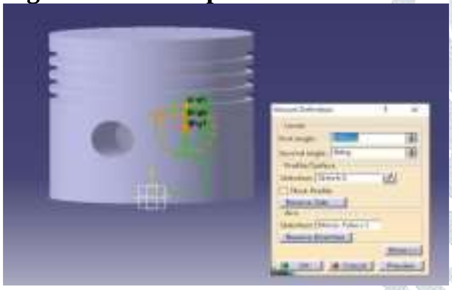


Fig 5.16: Groove operation at the Pin

Fig 5.17: Mirror operation of Groove at Pin

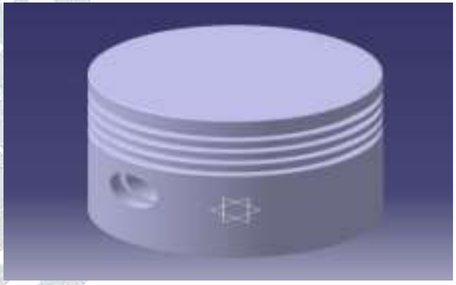


Fig 5.18: Design of the Piston

VI.MESHING OF THE PISTON

Meshing software(HYPERMESH):

Altair Hyper Mesh™ could be a market-leading, multi-disciplinary finite component pre-processor, that manages the generation of the biggest, most complicated models, beginning with the import of a CAD pure mathematics to commercialism ready-to-run thinker file.Over the last twenty years, Hyper Mesh has evolved into the leading premier pre-processor for idea and sound reproduction modeling. The advanced pure mathematics associated meshing capabilities give an atmosphere for speedy model generation. The capability to make high notch network apace is one in all Hyper Cross section's center skills.

shut the Loop Between CAD and FEA: Extract shell meshes straight from a thin pure mathematics further as thickness assignments with the powerful Mid-map Mesh Generation tools.Extract composite data from maths files and transfer it to finite half data with lowest user interaction.Retrieve 3D CAD geometries from finite half models to talk vogue direction to vogue and engineering teams.

CAPABILITIES: Best in school Meshing Mesh Morphing Batch Meshing High Fidelity Meshing

High Fidelity Meshing: Surface meshing Solid map hex meshing characin fish meshing
CFD meshing SPH meshing

CAD Interoperability: active Mesh provides import and export support for industry-leading CAD information formats. Moreover, Hyper Mesh has sturdy tools to clean up foreign pure mathematics to permit for the economical generation of high-quality meshes. Boundary conditions may also be applied on to pure mathematics for automatic mapping to underlying parts.

CATIA and CATIA CompositeLink FiberSim IGES (import and export) Intergraph
JT (import and export) Para solid (import and export) ProE and CREO
SolidWorks STEP (import and export) Tribon UG

Connectors: Connectors square measure geometric entities accustomed connect pure mathematics or iron entities. they are accustomed produce spot- and seam welds, adhesives, bolts or lots. Connectors square measure usually accomplished from geometric entities into numerous thinker specific iron representations. it's potential to unfulfilled them to vary the illustration to a special sort or thinker profile on resulting realization.

Composites: HyperMesh holds robust options for modeling extremely troublesome composites structures. Ply entities permit shaping the form of each single layers supported pure mathematics or parts. The laminate entity defines the stacking order of a composite half. The composites definition is generic and may be accomplished into several thinker profiles.

CAE {solver|problem thinker|convergent thinker|thinker} Interfacing: HyperMesh supports variety of assorted solver formats for each import and export. together with absolutely supported solvers, Hyper Mesh provides a very tailored atmosphere (user profile) for each supported thinker. It conjointly provides the pliability to support further solvers through a singular and straightforward interfacing language

Meshing method

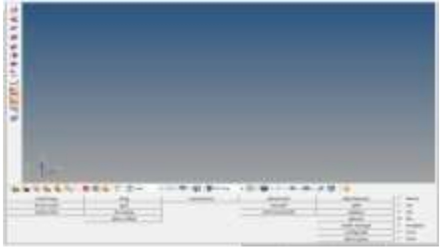


Fig 6.1: Hyper mesh Workspace

Fig 6.2: Importing model

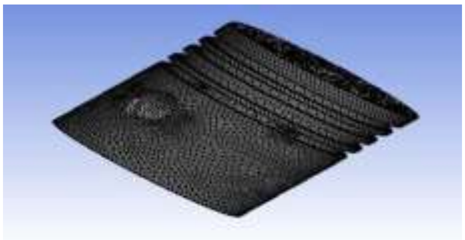


Fig 6.3: Mesh of the Piston

VII. ANALYSIS OF THE PISTON

Analysis software(ANSYS): ANSYS could be a software package package that enables you to digitally model planet phenomena. It uses computer-based numerical techniques to resolve physics issues. The vary of issues ANSYS will solve is vast and will be something from fluid flow, heat transfer, stress analysis and additional. The real power of associate FEA or CFD package like ANSYS is that it will solve issues that don't seem to be amenable to associate analytical approach. That is, they are doing not have commonplace formulae. Now, with the arrival of low-cost utility computing within the type of cloud, you'll be able to extremely push the boundaries of what are often shapely on the pc.

Analysis process:

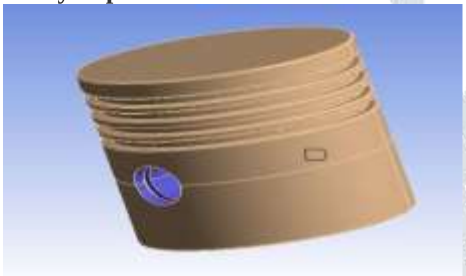


Fig 7.1: Fixed Support

Fig 7.2: Friction-less Support

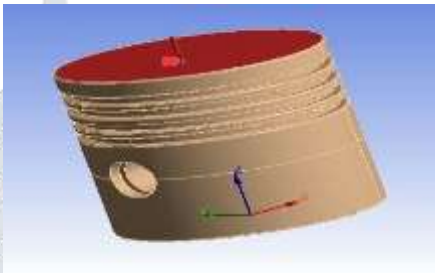


Fig 7.3: Pressure Load

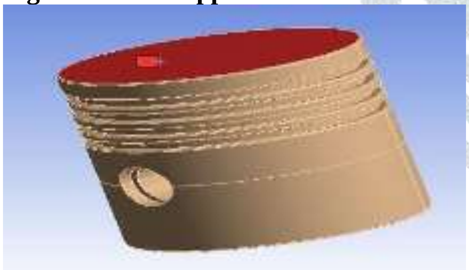


Fig 7.4: Temperature Load

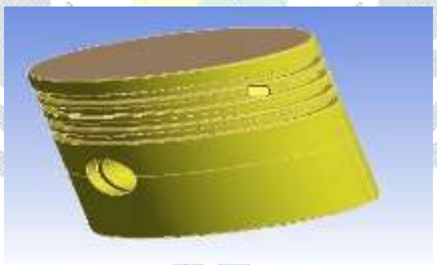


Fig 7.5: Convectional Support

VIII.FINITE ELEMENTANALYSIS

Introduction: Finite component Analysis (FEA) could be a computer-based numerical technique for calculative the strength and behavior of engineering structures. It are often wont to calculate deflection, stress, vibration, buckling behaviour and lots of different phenomena. It can also be wont to analyze either little or largescale deflection beneath loading or applied displacement. It uses a numerical technique referred to as the finite component technique (FEM). In finite component technique, the particular time is delineated by the finite parts. These parts square measure thought-about to be joined at such joints referred to as nodes or nodal points.In this project finite component analysis was applied mistreatment the FEA software package ANSYS. the first unknowns during this structural analysis square measure displacements and different quantities, like strains, stresses, and reaction forces, square measure then derived from the nodal displacements.

Static analysis: Static analysis deals with the conditions of equilibrium of the bodies acted upon by forces. A static analysis are often either linear or non-linear. every kind of non-linearities square measure allowed like giant deformations, plasticity, creep, stress stiffening, contact parts etc. this chapter focuses on static analysis.

Transient Thermal Analysis: A transient thermal analysis calculates temperatures and fluxes in your model over a specific time vary. If you're not inquisitive about the variation of temperature over time, you must use steady thermal analysis instead. you'll be able to direct style Simulate to report full results or temperature hundreds at such time intervals.

IX. RESULTS

Analysis Results:

Static Structural Analysis Results:

Total Deformation of the Piston:

Aluminium Alloy

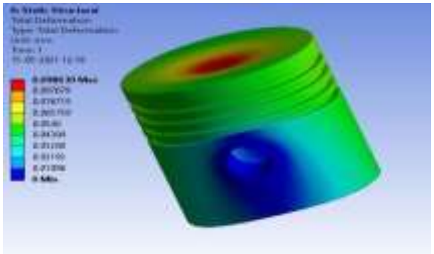


Fig 9.1.1: Total Deformation

Magnesium Alloy

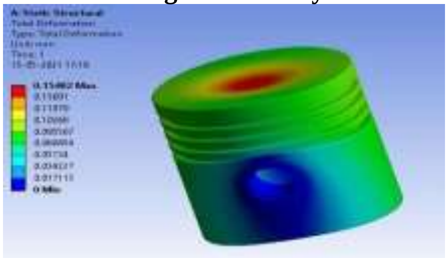


Fig 9.1.2: Total Deformation

Titanium Alloy

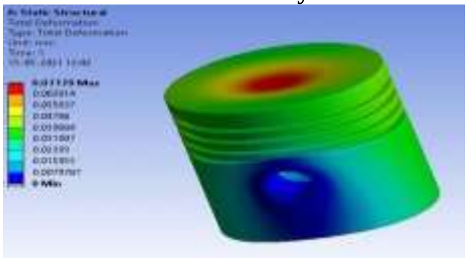


Fig 9.1.3: Total Deformation Alloy

Directional Deformation of the Piston:

Aluminium Alloy

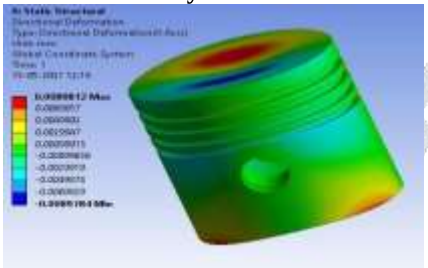


Fig 9.1.4: Directional Deformation

Magnesium Alloy

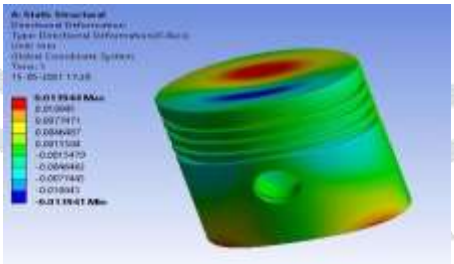


Fig 9.1.5: Directional Deformation

Titanium Alloy

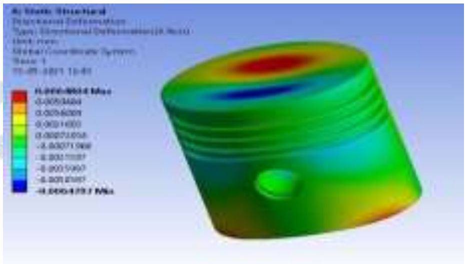


Fig 9.1.6: Directional Deformation

Max. Principal Stress of the Piston:

Aluminium Alloy

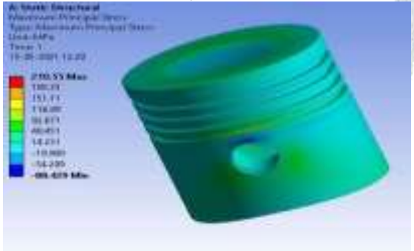


Fig 9.1.7: Max. Principal Stress

Magnesium Alloy

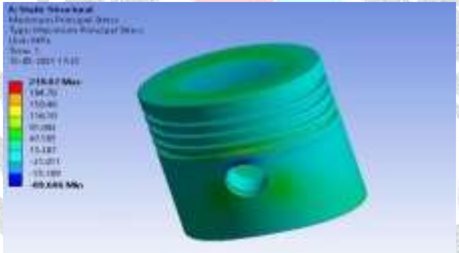


Fig 9.1.8: Max. Principal Stress

TitaniumAlloy

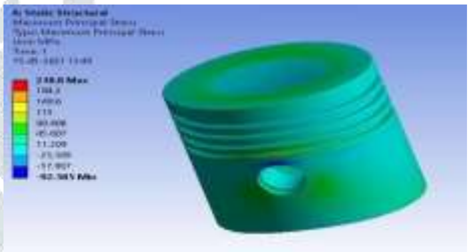


Fig 9.1.9: Max. Principal Stress

Shear Stress of the Piston:

Aluminium Alloy

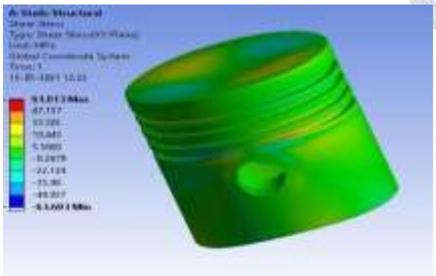


Fig 9.1.10: Shear Stress

Magnesium Alloy

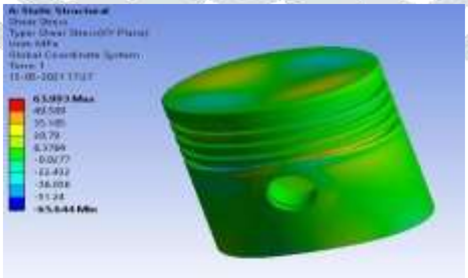


Fig 9.1.11: Shear Stress

Titanium Alloy

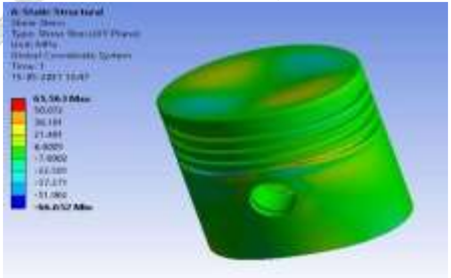


Fig 9.1.12: Shear Stress

Shear Elastic Strain of the Piston:

Aluminium Alloy

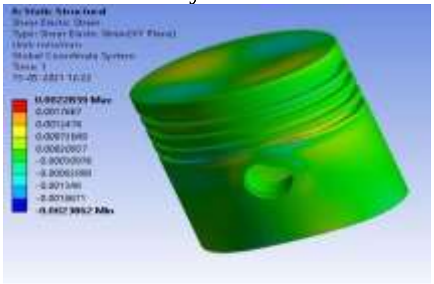


Fig 9.1.13: Shear Elastic Strain

Magnesium Alloy

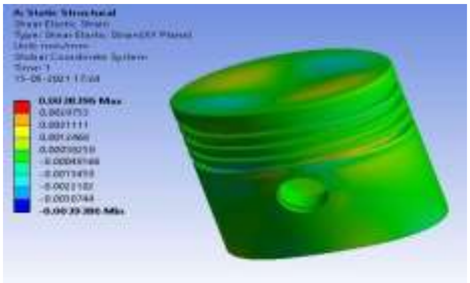


Fig 9.1.14: Shear Elastic Strain

Titanium Alloy

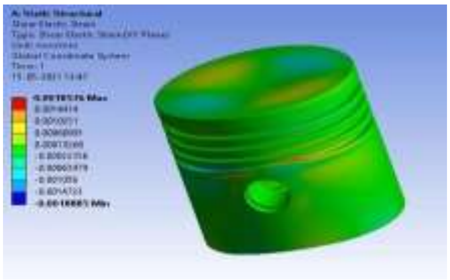


Fig 9.1.15: Shear Elastic Strain

Equivalent Stress of the Piston:

Aluminium Alloy

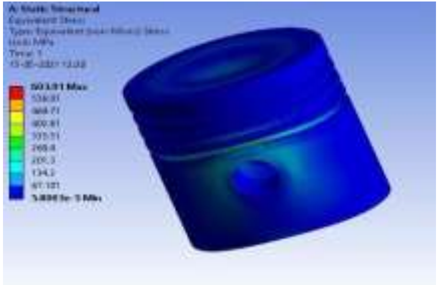


Fig 9.1.16:Equivalent Stress

Magnesium Alloy

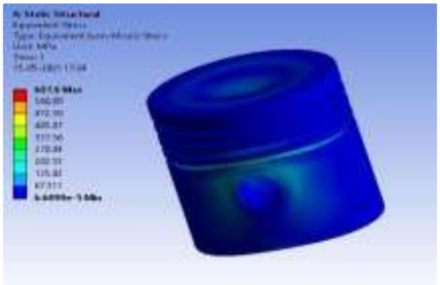


Fig 9.1.17: Equivalent Stress

Titanium Alloy

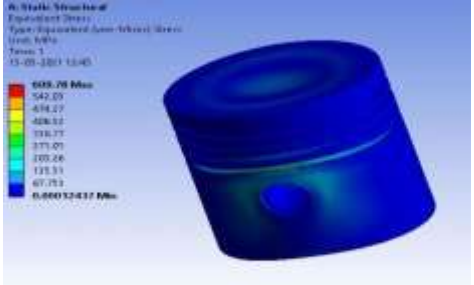


Fig 9.1.18:Equivalent Stress

Equivalent Elastic Strain of the Piston:

Aluminium Alloy

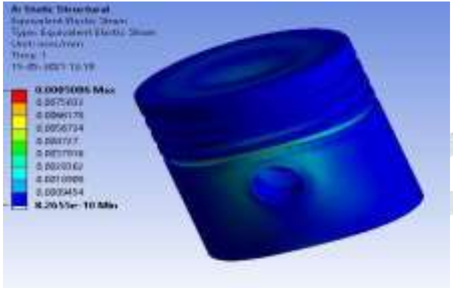


Fig 9.1.19: Equivalent Elastic Strain

Magnesium Alloy

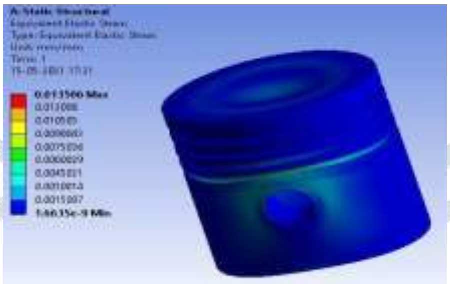


Fig 9.1.20:Equivalent Elastic Strain

Titanium Alloy

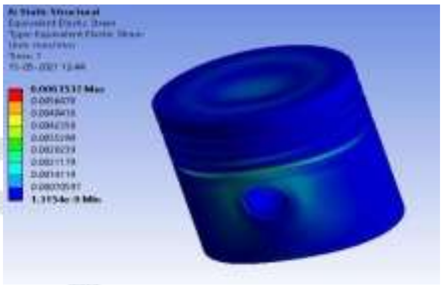


Fig 9.1.21: Equivalent Elastic Strain

Max. Shear Stress of the Piston:

Aluminium Alloy

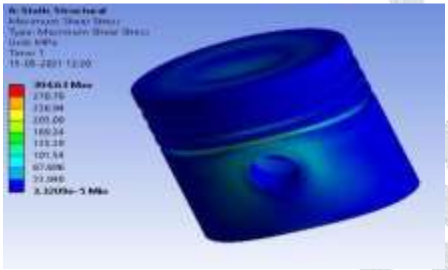


Fig 9.1.22: Max. Shear Stress

Magnesium Alloy

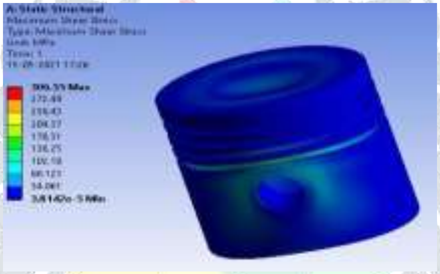


Fig 9.1.23: Max. Shear Stress

Titanium Alloy

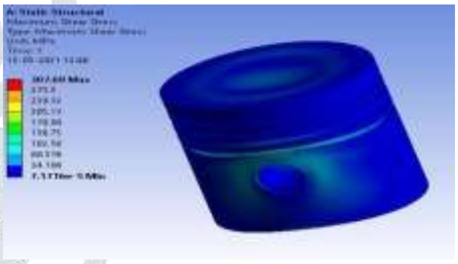


Fig 9.1.24: Max. Shear Stress

Max. Shear Elastic Strain of the Piston:

Aluminium Alloy

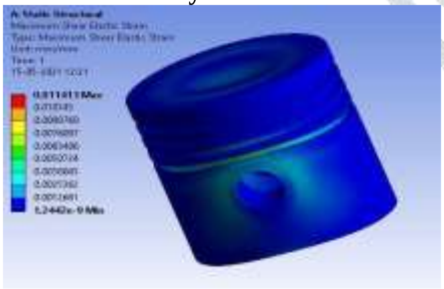


Fig 9.1.25: Max. Shear Elastic

Magnesium Alloy

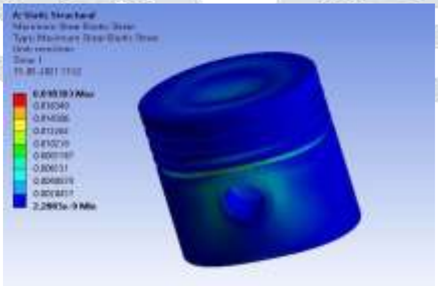


Fig 9.1.26: Max. Shear Elastic Strain

Titanium Alloy

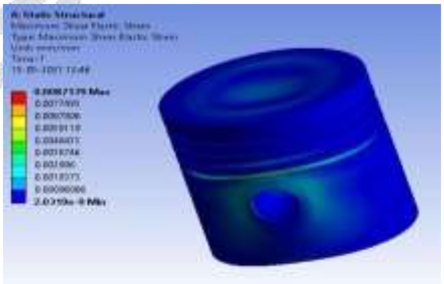


Fig 9.1.27: Max. Shear Elastic Strain

Normal Stress of the Piston:

Aluminium Alloy

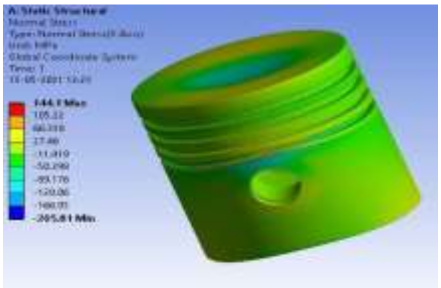


Fig 9.1.28: Normal Stress

Magnesium Alloy

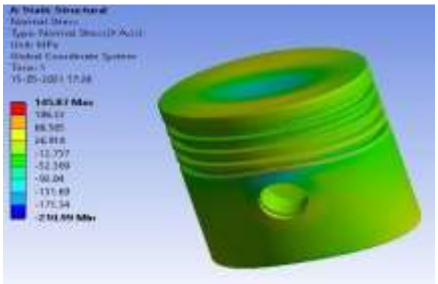


Fig 9.1.29: Normal Stress

Titanium Alloy

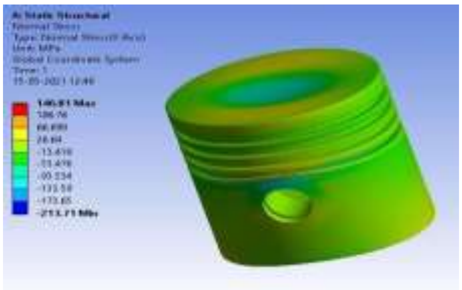


Fig 9.1.30: Normal Stress

Normal Elastic Strain of the Piston:

Aluminium Alloy

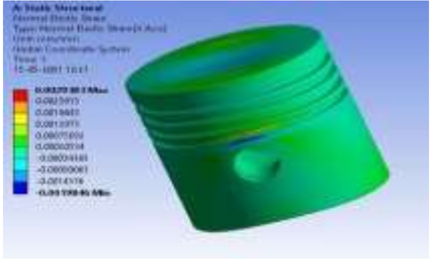


Fig 9.1.31: Normal Elastic Strain

Magnesium Alloy

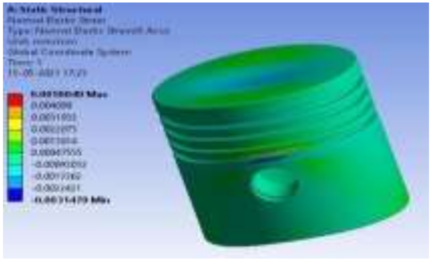


Fig 9.1.32: Normal Elastic Strain

Titanium Alloy

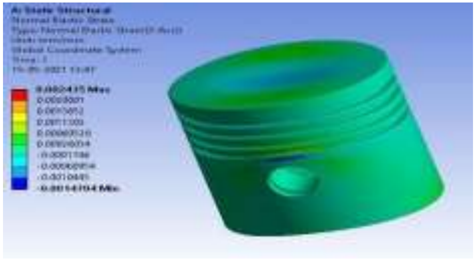


Fig 9.1.33: Normal Elastic Strain

Strain Energy of the Piston:

Aluminium Alloy

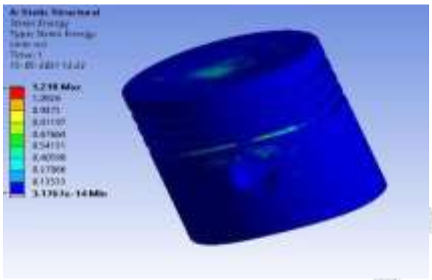


Fig 9.1.34: Strain Energy

Magnesium Alloy

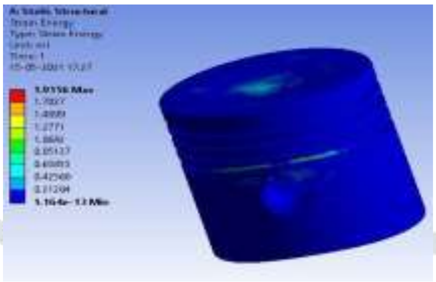


Fig 9.1.35: Strain Energy

Titanium Alloy

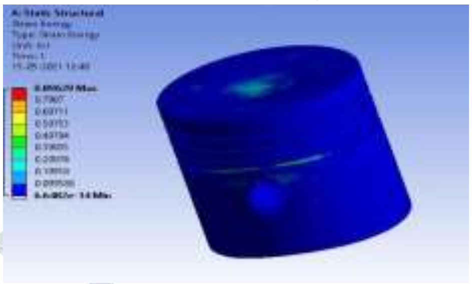


Fig 9.1.36: Strain Energy

Safety Factor of the Piston:

Aluminium Alloy

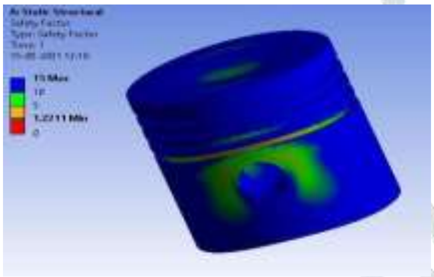


Fig 9.1.37: Safety Factor

Magnesium Alloy

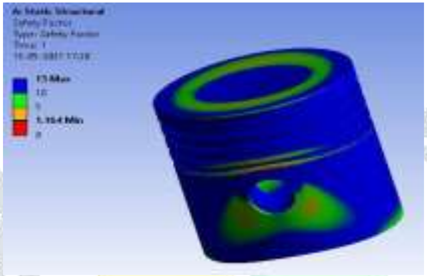


Fig 9.1.38: Safety Factor

Titanium Alloy

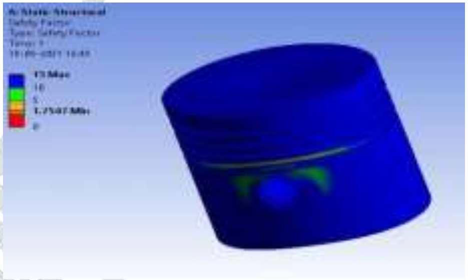


Fig 9.1.39: Safety Factor

Transient Thermal Analysis Results:

Temperature of the Piston:

Aluminium Alloy

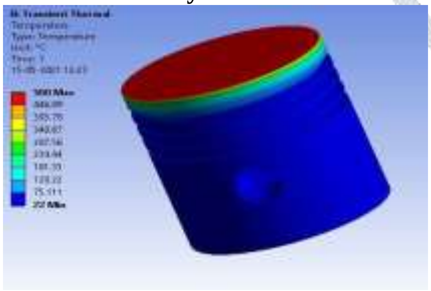


Fig 9.2.1: Temperature of the Piston

Magnesium Alloy

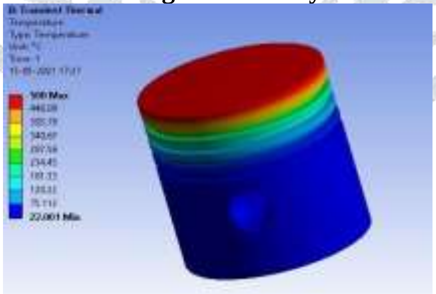


Fig 9.2.2: Temperature of the Piston

Titanium Alloy

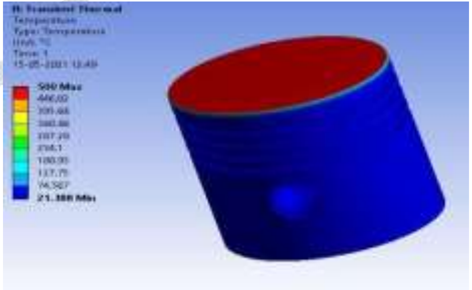


Fig 9.2.3: Temperature of the Piston

Total Heat Flux of the Piston:

Aluminium Alloy

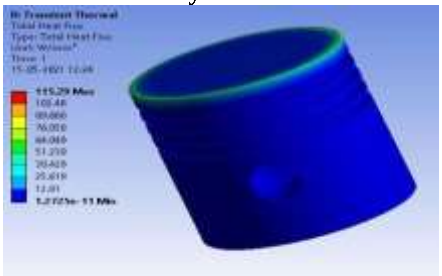


Fig 9.2.4: Total Heat Flux

Magnesium Alloy

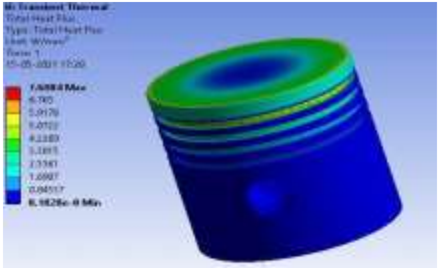


Fig 9.2.5: Total Heat Flux

TitaniumAlloy

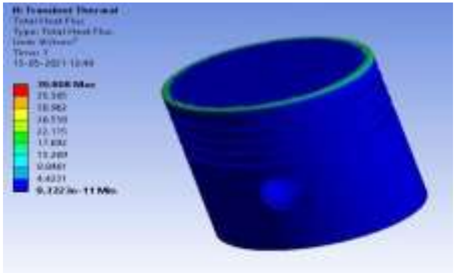


Fig 9.2.6: Total Heat Flux

Tabular Results

Static Structural Tabular Results

Total Deformation:

S.no	Marterial	Total deformation, mm	
	Alloy	minimum	maximum
1	Al	0	0.0986
2	Magnesium	0	0.15
3	Titanium	0	0.07179

Table 9.1.1: Total Deformation of the materials

Ddirectional deformation:

S.no	Marterial	Ddirectional deformation, mm	
	Alloy	minimum	maximum
1	Al	-8.90E-03	8.98E-03
2	Magnesium	-1.39E-02	1.39E-02
3	Titanium	-6.48E-03	6.48E-03

Table 9.1.2: Directional Deformation of the materials

Max. principal stress:

S.no	Material	Max. principal stress, Mpa	
	Alloy	minimum	maximum
1	Al	-88.429	219.55
2	Magnesium	-89.606	219.07
3	Titanium	-92.585	218.8

Table 9.1.3: Max. Principal Stress of the materials

Shear stress:

S.no	Material	Shear stress, Mpa	
	Alloy	minimum	maximum
1	Al	-63.693	61.0013
2	Magnesium	-65.99	63.933
3	Titanium	-66.652	65.56

Table 9.1.4: Shear Stress of the materials

Shear elastic strain:

S.no	Material	Shear elastic strain, mm/mm	
	Alloy	minimum	maximum
1	Al	-2.39E-03	2.29E-03
2	Magnesium	-3.94E-03	3.84E-03
3	Titanium	-1.89E-03	1.86E-03

Table 9.1.5: Shear Elastic Strain of the materials

Equivalent stress:

S.no	Material	Equivalent stress, Mpa	
	Alloy	minimum	maximum
1	Al	5.80E-05	603.91
2	Magnesium	6.61E-05	607.6
3	Titanium	1.24E-04	609.78

Table 9.1.6: Equivalent Stress of the materials

Equivalent elastic strain:

S.no	Material	Equivalent elastic strain, mm/mm	
	Alloy	minimum	maximum
1	Al	8.27E-10	8.51E-03
2	Magnesium	1.66E-09	1.35E-02
3	Titanium	1.32E-09	6.35E-03

Table 9.1.7: Equivalent Elastic Strain of the materials

Max. shear elastic strain:

S.no	Material	Max. shear elastic strain, mm/mm	
	Alloy	minimum	maximum
1	Al	1.24E-09	0.011413
2	Magnesium	2.29E-09	0.018393
3	Titanium	2.03E-09	0.008179

Table 9.1.8: Max. Shear Elastic Strain of the materials

Max. shear stress:

S.no	Material	Max. shear stress, Mpa	
	Alloy	minimum	maximum
1	Al	3.32E-05	304.63
2	Magnesium	3.81E-05	306.55
3	Titanium	7.17E-05	307.69

Table 9.1.9: Max. Shear Stress of the materials

Normal stress:

S.no	Material	Normal stress, Mpa	
	Alloy	minimum	maximum
1	Al	-205.81	144.1
2	Magnesium	-210.99	145.87
3	Titanium	-213.71	146.81

Table 9.1.10: Normal Stress of the materials

Normal elastic strain:

S.no	Material	Normal elastic strain, mm/mm	
	Alloy	minimum	maximum
1	Al	-1.98E-03	2.94E-03
2	Magnesium	-3.15E-03	5.00E-03
3	Titanium	-1.48E-03	2.44E-03

Table 9.1.11: Normal Elastic Strain of the materials

Transient Tharmal Tabular Results:

Temperature:

S.no	Material	Temperature, °C	
	Alloy	minimum	maximum
1	Al	22.00	500.00
2	Magnesium	22.01	500.00
3	Titanium	21.39	500.00

Table 9.2.1: Temperature of the materials

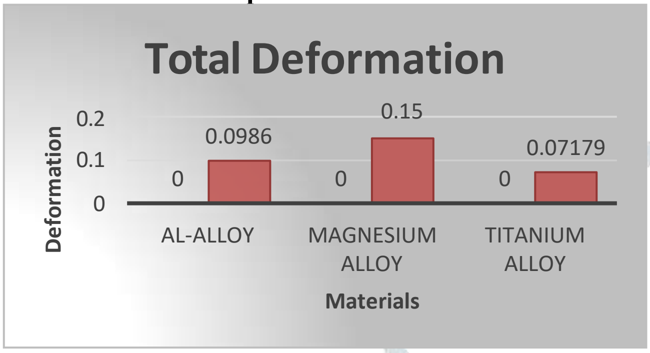
Total Heat Flux:

S.no	Material	Total Heat Flux, W/mm2	
	Alloy	minimum	maximum
1	Al	1.28E-11	115.29
2	Magnesium	8.12E-08	7.6084
3	Titanium	9.33E-11	39.808

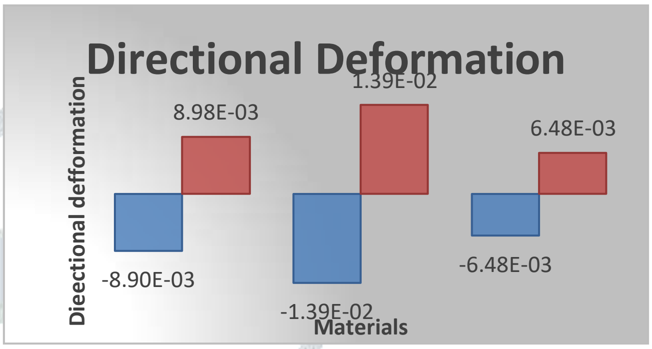
Table 9.2.1: Total Heat Flux of the materials

Graphical Results:

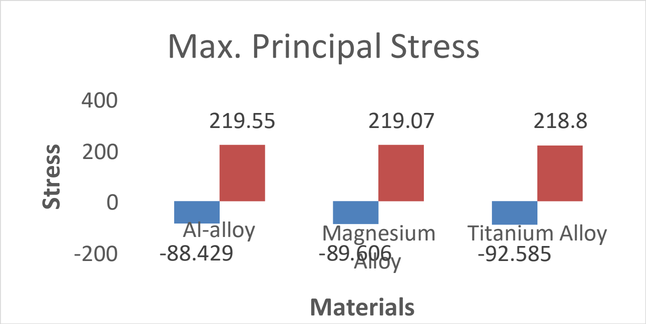
Static Structural Graphs:



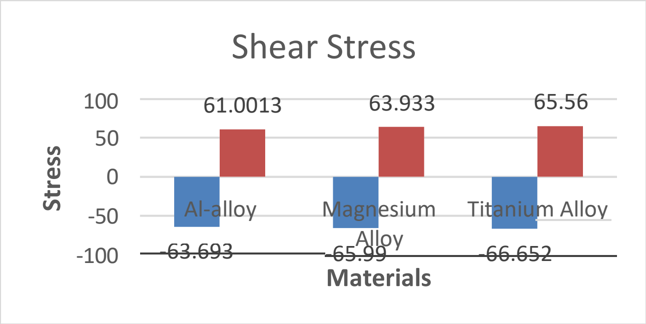
Graph 9.1.1: Total Deformation of the materials



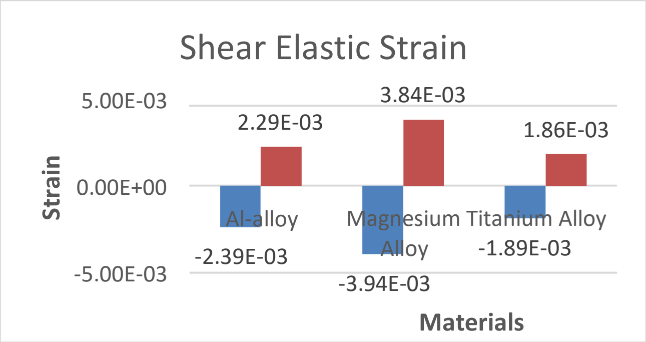
Graph 9.1.2: Directional Deformation of the materials



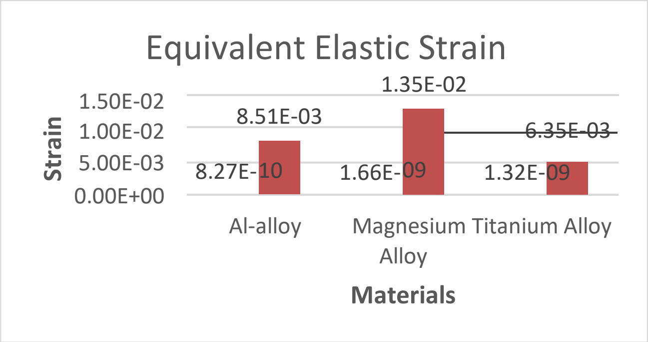
Graph 9.1.3: Max. Principal Stress of the materials



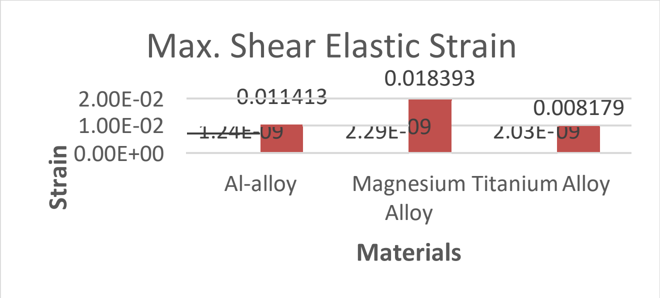
Graph 9.1.4: Shear Stress of the materials



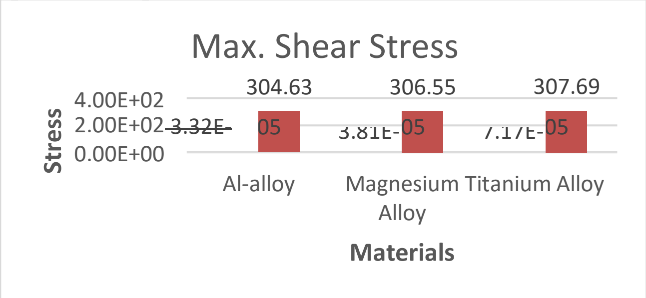
Graph 9.1.5: Shear Elastic Strain of the materials



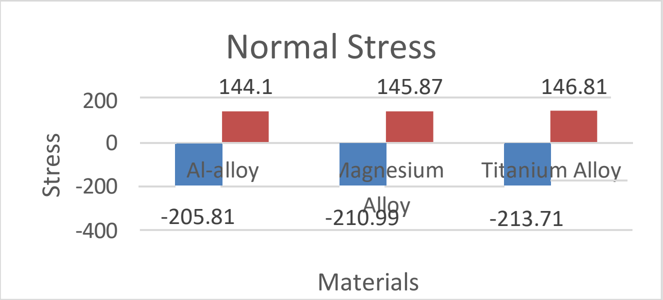
Graph 9.1.6: Equivalent Elastic Strain of the materials



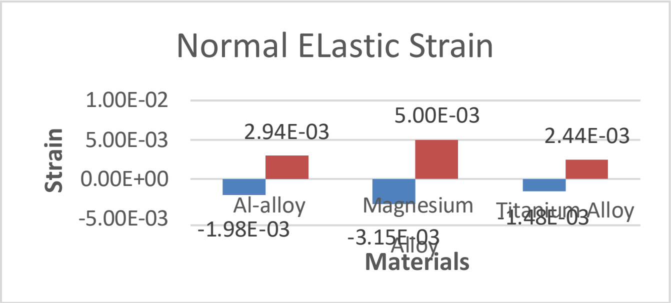
Graph 9.1.7: Max. Shear Elastic Strain of the materials



Graph 9.1.8: Max. Shear Stress of the materials

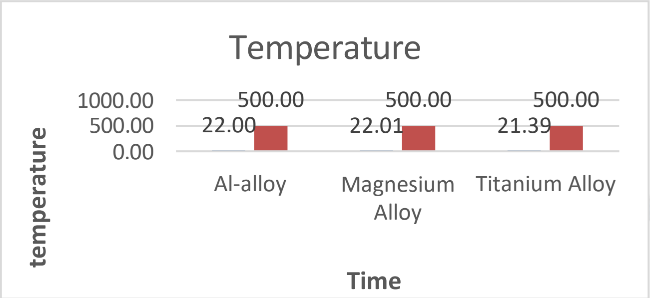


Graph 9.1.9: Normal Stress of the materials

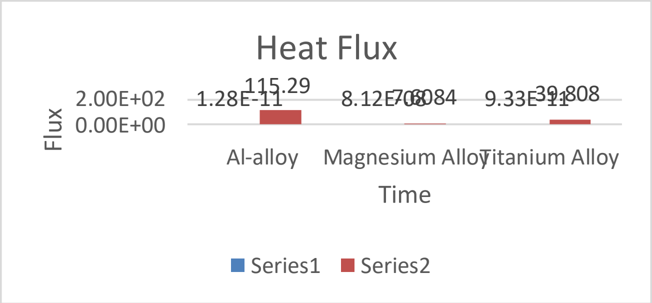


Graph 9.1.10: Normal Elastic Strain of the materials

Transient Thermal Analysis Graphs



Graph 9.2.1: Temperature of the materials



Graph 9.2.1: Total Heat Flux of the materials

CONCLUSION

The deformation of titanium alloy is 0.07179mm lower than the other two materials. Also The FOS of Titanium alloy is 1.7 is higher than the other materials, so further development of high power engine using this material is possible.

S.no	Material	Total deformation, mm	
	Alloy	Minimum	maximum
1	Al	0	0.0986
2	Magnesium	0	0.15
3	Titanium	0	0.07179

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