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Design and Optimization of Engine Truss Mount Bracket

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Abstract: An aircraft consists of large components which are connected by discontinuities like joints which are imminent while they play an important role and are being subjected to failure under cyclic loading conditions. The occurrence of high stress concentration and geometric irregularities which determine the primary load carrying capacity effects the performance of such brackets. The failure of which may cause unexpected failure of the system there by the failure of aircraft. A primary load carrying structure of an aircraft are longerons, stringers, spars and bulkhead. These structures are further supported by splicing, truss structures and brackets etc. This bracket transfers load from the engine to a truss structure effectively. A bracket being considered as a part of engine assembly that is safe from failure. The criteria being on weight in regard to the various parts of the aircraft is looked at and studied, having to consider overall – strength. The static analysis (global) will be carried out for the study of the effects of these loads on considered points of the aircraft using the FEA software HYPERMESH 13.0. The optimization is carried out on the bracket located at the hard points on each of the bulkheads of the entire length of the aircraft by first considering the described nature of the load and its effect on the bracket. Strength check is performed for the initial model and the optimised model to access the performance under the load conditions. A weight optimization of above 10% is achieved with the proposed model having the stress within the acceptable limits.
Keywords: Tapered lug bracket, Static structural analysis, weight optimization, boundary conditions, load path.

I. INTRODUCTION

The preference in the design stage of an aircraft is the all-up weight load saving which is the key factor in consideration that will result in increased performance. The design of engine truss mount bracket is approached upon considering multiple load type cases according to the aviation standards. The design change would be based on multiple load paths arising from different load conditions. The engine of the aircraft is supported by an engine bracket which transfers the load to the bulkhead through the truss structures and truss mount brackets. Six truss mount brackets are used in each bulkhead section of aircraft HTT-40 (Hindustan Turbo Trainer) engine mounting structure. Out of these six truss mount brackets the top L.H.S bracket is considered for modeling and analysis of stress and displacement after which the analysed bracket is redesigned. The motor mount section which is exposed to calibration and the weight optimization is fitted in the aircraft HTT-40 (Hindustan Turboprop Trainer) which is proposition for an indigenous swap for the Indian Air Force's resigned HPT-32 Deepak as an essential coach. The engine The HTT-40 will be an all-metal tandem seat airplane is controlled by a 1,100 HP turbo-prop motor. The turbo Prop trainer aircraft has an all metal a total equipped digital-engine or control of electronics.

A bracket being considered as a part of engine assembly that is safe from failure. This bracket transfers load from the engine to a truss structure effectively. The criteria being on weight in regard to the various parts of the aircraft is looked at and studied, having to consider overall – strength. The static analysis (global) will be carried out for the study of the effects of these loads on considered points of the aircraft. The optimization is carried out on the bracket located at the hard points on each of the bulkheads of the entire length of the aircraft by first considering the described nature of the load and its effect on the bracket. The material considered suitable for the component is NCM steel alloy for the double lug type bracket which is mounted to the bulkhead through bolts.

II. METHODOLOGY

The important characteristics of the tapered lug bracket is determined by performing static structural analysis and then studied for load distribution and load paths, followed by weight optimization. Applying constraints defines the drawing until the sketch is fully constrained. Converting the 2D draft to 3D part by using various software commands. After the part file is defined according to the drawing it is exported. The export of the part file is in the IGES format to ALTAIR HYPERMESH software for the purpose of pre-processing. Then the solution for the defined material properties, boundary conditions and loads is calculated after the part is input to ALTAIR OPTISTRUCT in .fem file format.

The post processing is then carried in ALTAIR HYPERVIEW where the static structural analysis carried out and displacements and principle stresses, Vonmises stress is noted the (part file is in .h3d format).For the purpose of optimization, the part is again remodelled in NX8.5 from the basic model extra mass is added for finding the proper load path during optimization. Then the part is exported to SOLID THINKING INSPIRE for optimization. The part is divided into design and non-design space. The analysis is also carried after defining material properties, boundary conditions and loads. The number of iterations are done keeping strength and weight as priority and the results obtained is compared for obtaining the optimum design space.

III.DESIGN AND ANALYSIS

A. *Defined Engine Truss Mount Bracket*

The engine truss mount bracket considered is a tapered lug bracket made of NCM steel alloy. There is a uniform taper to this bracket keeping in mind the development of stress concentration. A suitable thickness is chosen for strength and stress conditions. A surface of the model is generated and imported in hypermesh. The Data Item provided by ESDU gives important data to determine out of plane and in plane loads and there effect on tapered lug like displacement type and its duration along with the initiating magnitude. The lug analysis is complex in nature as there are simultaneous, interacting failure modes. Associated with different areas of the lug are the failure modes. The rupture of the bracket is observed under axial in plane force leading to modes under tension forces and modes of rupture under shear forces causing displacements that cannot be reversed along with mode which combines both. The decision on deformation type depends critical modes of failure.

1) *Composition of NCM Steel*

%	C	M n	S i	S	P i	N i	C r	M o
S99	.36- .44	0.45-0.70	0.10-0.35	.015	.025	2.3- 2.8	0.5- 0.8	0.4- 0.6

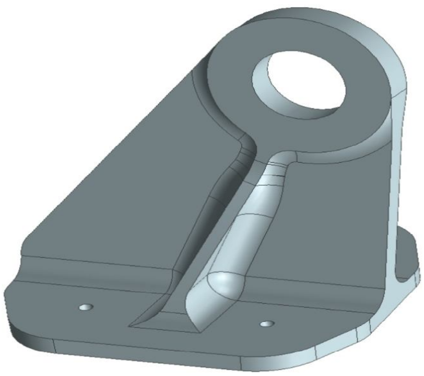

Fig 1: Engine Truss Mount Bracket

B. *Load and Boundary Conditions*

The engine mount bracket is considered as a part of the engine with a gross weight of 2,800kg, having a fuel capacity 450kg the power plant is a Honeywell Garrett TPE331-12B turboprop with 1100hp power.The maximum torque considered as input is 6056 Nm, with a thrust of 9700 N at idle propeller speed of 2000rpm. The bracket is bolted to the bulkhead hence it is constrained to have no translational and rotational movements of six degree of freedom. The material used for the bracket is NCM steel which is steel with major compositions as nickel (Ni), chromium (Cr), molybdenum (Mo). This steel has various desired properties making it suitable for use in aircraft structural components like excellent hardenability, high tensile strength, high impact strength, good weldability, and good machinable property. It has 0.2% proof stress of value 1080Mpa, Hardness value 363-416BHN. The given loads in global coordinate system and their transformation into local coordinate system are tabulated below,

1) *Loads at the Lug end of the Bracket is Given*

F_x = 15.5 KN

F_y = 6.6 KN

F_z is considered negligible. The Air Force method is best use to evaluate the lug for bearing failure in case of axially loaded lugs also for shear-out failure, hoop tension failure. Bearing strength take to account all the three load failure cases and provides analogy for bearing, shear-out, and hoop tension.

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2) Forces Calculated

GIVEN FORCES(N)		CALCULATED FORCES(N)	
POINT A	POINT B	POINT A	POINT B
Fx= 25828	Fx= -14186	Fx'= 16979.224	Fx'= -14282.35
Fy= -821	Fy= 3796	Fy'= -19382.65	Fy'= 3171.77
Fz= 13101	Fz= -685	Fz'= 13036.48	Fz'= 1472.31

The angles θ between the global coordinate axis and the local coordinate axis are calculated and tabulated below at point A and point B respectively. There are twenty load cases for an engine and each load has three reactions which are F_x , F_y , F_z acting along the mutually perpendicular axes at the bay end of all six brackets.

3) Angles Measured in NX8.5

Θ11 =32.15	Θ21 =106.36	Θ31 =63.090
Θ12 =111.3243	Θ22 =71.80	Θ32 =28.6406
Θ13 =113.3227	Θ23 =154.77	Θ33 =80.9201
Θ11 =10.5945	Θ21 =96.5611	Θ31 =81.71
Θ12 =96.56	Θ22 =76.4608	Θ32 =15.100
Θ13 =98.281	Θ23 =164.899	Θ33 =77.461

The transformation formula used is

$$A' = \begin{pmatrix} A_1' \\ A_2' \\ A_3' \end{pmatrix} * \begin{pmatrix} \cos\theta_{11} & \cos\theta_{12} & \cos\theta_{13} \\ \cos\theta_{21} & \cos\theta_{22} & \cos\theta_{23} \\ \cos\theta_{31} & \cos\theta_{32} & \cos\theta_{33} \end{pmatrix}$$

Where θ_{11} is the angle between the local datum axis and the global datum axis in x- direction. Similarly the other axes angles are calculated using command simple angle. The critical loads are applied boss and bearing interface region of the bracket of all these reactions is under study. Few of these load cases are included below. The symmetry portion of the lug is modeled for ease and use of tri and quad elements is made in 2D to create the geometry of the model. Thus a surface is created using 2D elements and each element is assigned a constrain and boundary condition. The lug hole is meshed with a technique to reduce stress concentration as far as possible. To achieve a converged solution the iterations were performed and the model was checked for the displacements and stress for each trial. The best suited trial is worked upon for final quality check before being imported for weight optimisation in which the weight is reduced to maximum permissible and stiffness of the bracket is constrained not to vary the load transfer characteristics, the material around this path is scored and worked upon for best results.

4) Loads and Moments on Powerplant at Manoeuvres

CASES	FLIGHT CONDITIONS	Fx	Fy	Fz
1	Arrested landing	-15556	343	-3468
2	Side load (FAR23)	-9822	-5392	-3468
3	Side load (FAR 23)	-9822	6078	-3468
4	Yaw acceleration(L.H)	-9802	9447	-36466
5	Yaw acceleration (R.H)	-9841	-8761	3468
6	Roll yaw (L.H)	-9802	3781	-3474
7	Roll yaw (R.H)	-7841	-2957	-3474
8	Pitch yaw	-16801	378	-7770
9	Pitch up	-10782	343	-22619
10	Pitch down	-9823	343	11025

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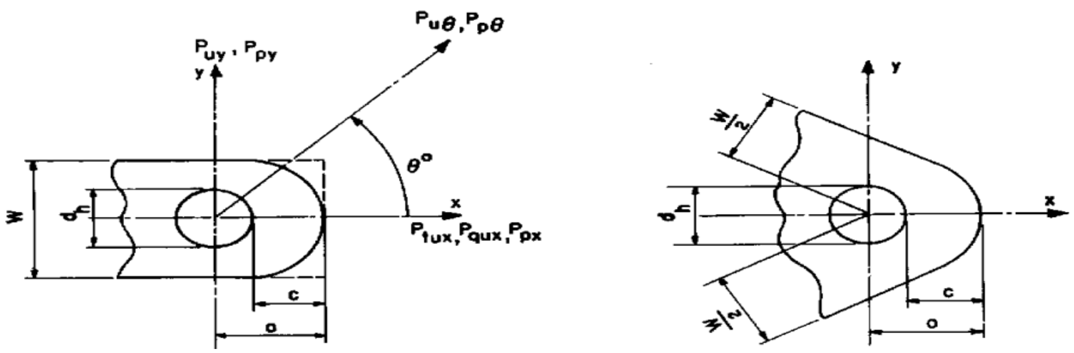
5) Input Form of HTT- 40 Engine Mount and Truss Load

ENGINE WEIGHT	We	Kg	229.50
PROPELLER WEIGHT	Wpr	Kg	74.840
STARTER WEIGHT	Ws	Kg	13.770
ENGINE MAX. THRUST	T	N	9700
PROPELLER SPEED	Np	Rpm	2000
MAX TORQUE	Q	Nm	6056

Analysis on the bracket was done in SolidThinking and the input for the analysis follows:
Material – NCM Steel
Material Specification – BS5S 99D
Yield Strength – 1080 Mpa
Poisson's Ratio – 0.29
Material Density – 7850 kg/m3
Part weight – 0.429 kg

C. Static Structural Analysis

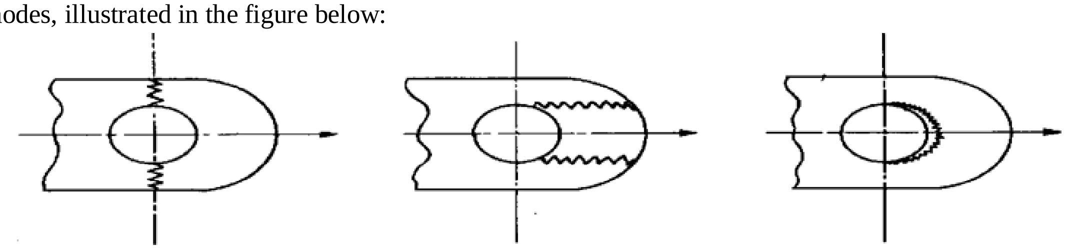
The Data Item provided by ESDU gives important data to determine out of plane and in plane loads and there effect on tapered lug like displacement type and its duration along with the initiating magnitude. The analysis of axially loaded lugs require two analyses one which describes the failure due to tension across the net section and the other which describes the shear out between the pin and the lug that eventually causes failure. Various factors which are a function of the lug geometry and the material properties is used like tension and bearing efficiency factors. These factors help in predicting the allowable loads that the lug is subjected to. Assumptions were made in assigning the stiffness of lug and the pin .RBE 2 connections are made in the region of the lug hole geometry which helps in continuity and load transfer. The same values of load and boundary conditions are used for each iteration performed.



Parallel – Sided Lug Tapered Lug

Fig 2: General Lug Geometry

The lug analysis is complex in nature as there are simultaneous, interacting failure modes. Associated with different areas of the lug are the failure modes, illustrated in the figure below:



Tension Shear Tear- out Bearing

Fig 3 : Modes of Failure

The rupture of the bracket is observed under axial in plane force leading to modes under tension forces and modes of rupture under shear forces causing displacements that cannot be reversed along with mode which combines both. The decision on deformation type depends on the above mentioned modes of failure. Tensile rupture may be represented by a factor K_{tux}.

The Air Force method is best use to evaluate the lug for bearing failure in case of axially loaded lugs also for shear-out failure, hoop tension failure. Bearing strength take to account all the three load failure cases and provides analogy for bearing, shear-out, and hoop tension. The important dimensions for an axially loaded lug are shown in the figure below:

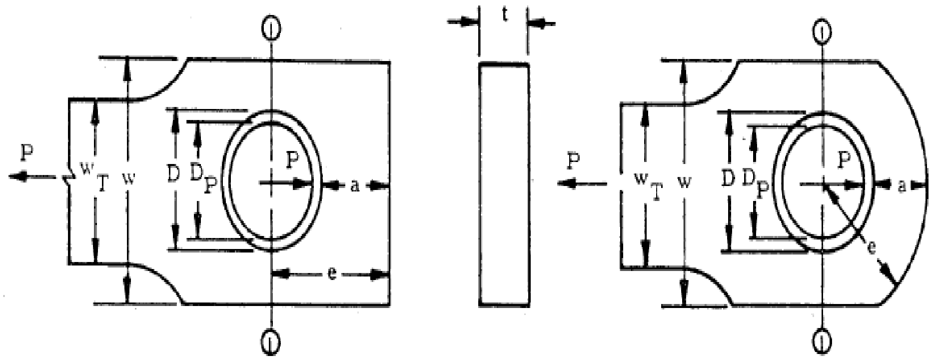


Fig 4 : Schematics of lugs loaded in tension

The expression for the force under transverse direction is given also the depicted are the force K uy graphed against A e /d h t in which curve (a) is for steel lugs and curve (b) is for aluminium alloy lugs. The effective area is given by the expression below

$P_{u\,y} = K_{u\,y} F_{tu\,m} d_h t$,

A_E = 6/ {(3/A1 + (1/A2) + (1/A3) + (1/A4)}.Guidance on how to obtain values of the areas A_1, A_2, A_3 and A_4 for lugs of tapered form

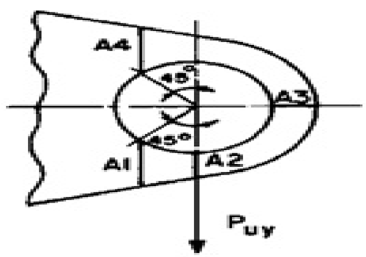


Fig 5: Area of Tapered lug

The expression for the force in transverse to cause failure is P py = K py*f tp*dht, where f tp a least force in regard to grain configuration, in the bracket plane. Magnitude of transverse displacement, K_{py}, are graphed $A_E/d_h t$. The bracket is under pin force in y- direction and develops stress due to shear and bearing force along the cross-section that causes rupture in transverse configuration. or a rupture due to tension around the end of the lug.

IV. CALCALUTION

The reference and measured values are as follows:
Applied Ultimate Axial load and Transverse Load – 15.5KN (P1 and P2), Hole Diameter – 19.05mm, Lug thickness – 9.525mm, Edge thickness – 25.4mm, Material Ult Strength (L and T) – 517 MPa and 468 Mpa, A1=A3 = 1.651mm and A2=A3 = 5.9mm.

1) *Shear Bearing Failure:* P'bru = Kbr * Ftux *Abr
With e/D = 1.33 and D/t = 2,
Kbr = 1.28
Abr = 19.05 * 9.525 = 181.45 mm2,
P'br = 517*1.28*181.45 = 120 KN.

2) Axial Tension Failure: P'tu = Kt * Ftu * At
Where, w = 50.8 mm, At = 302.4 mm2,
w/D = 67.81mm and
Kt = 0.88 ultimate axial efficiency factor
P'tu = 517 *0.88 *302.4 = 137 KN

3) Transverse Failure: P'tru = Ktru * Ftux * Abr
Where, Abr = 181mm2,
Aav = 6/((3/1.651)+(1/5.94)+(1/5.94)+(1/1.651)) = 55.483 ,
Aav/Abr = 0.304, Ktru = 0.39 UTE
P'tru = 468 * 0.387 * 181 = 33KN

4) Oblique Load Interaction
1.15 Fitting factor included.
Ra = 0.149 and Rtr = (1500*1.15)/7406 = 0.233
M.S. = (1/(0.149^1.6 + 0.233^1.6)^0.625) – 1 = 2.35.
As the desirable margin of safety is achieved the loads considered are safe to handle.

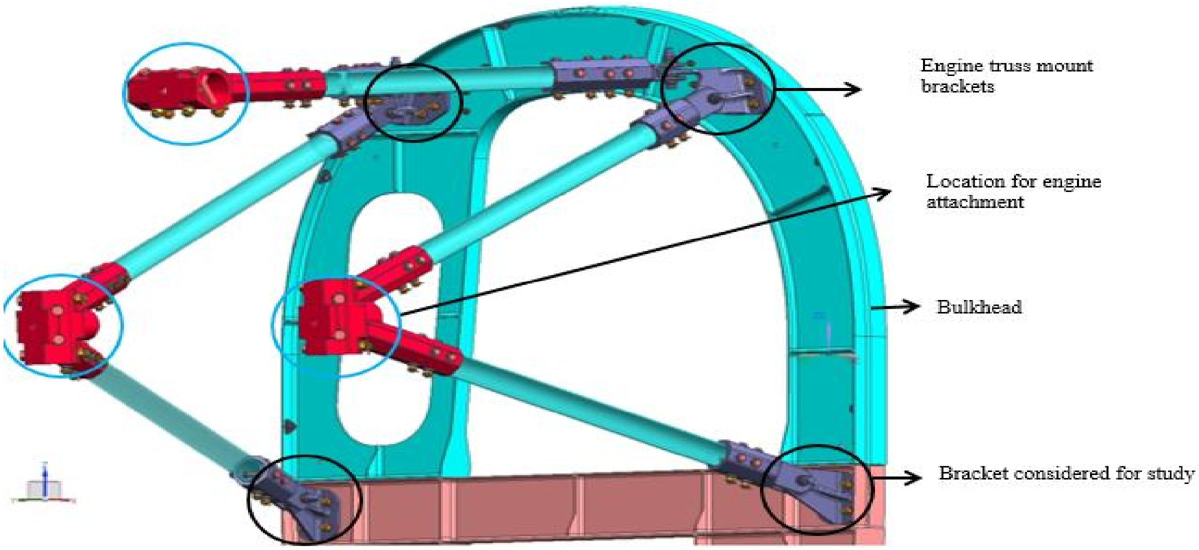


Fig 6 : Truss Structure

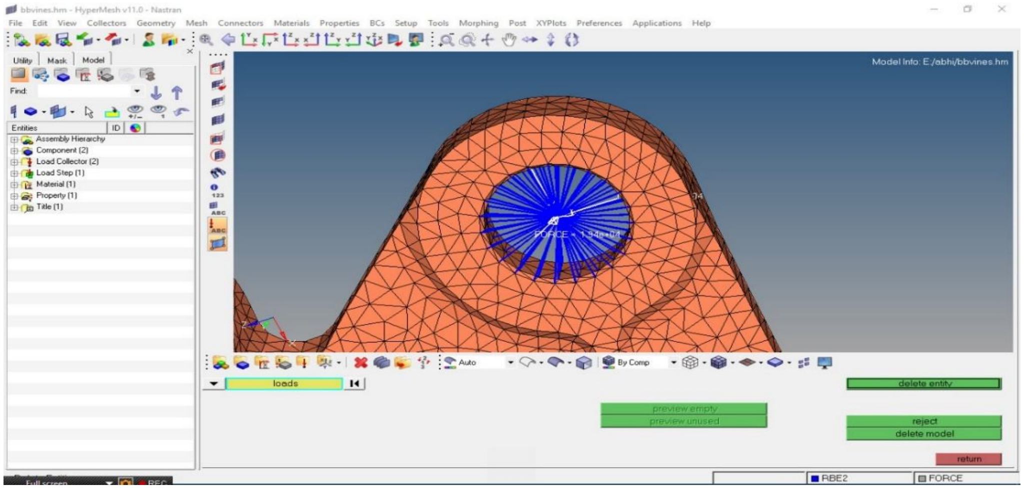


Fig 9 : RBE2 connectors used for applying forces at the centre of Lug

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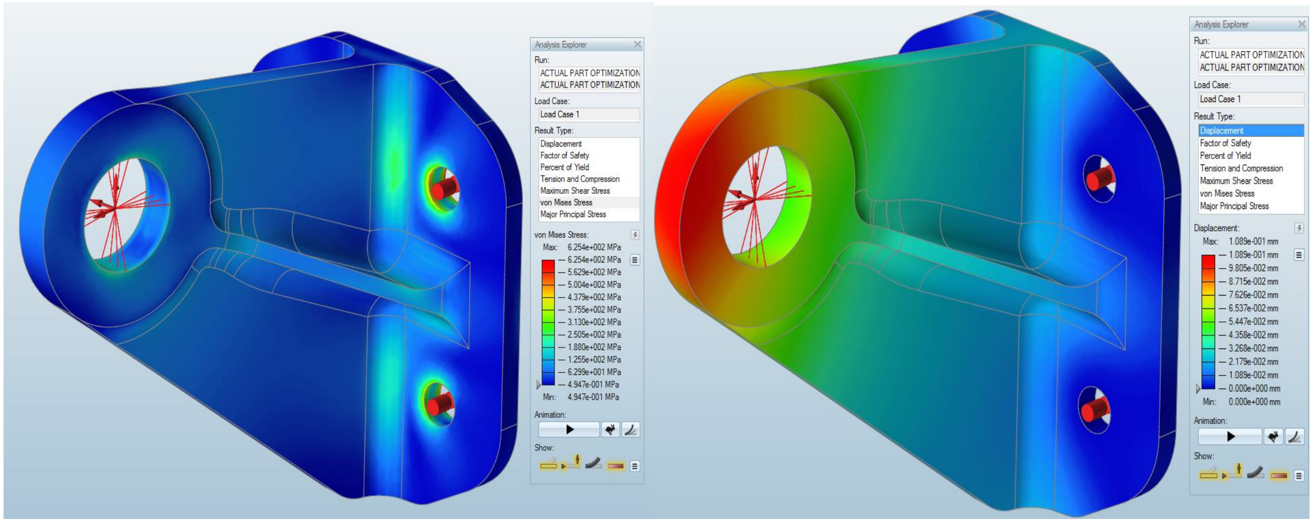


Fig 8 : Static Structural Analysis

Connectors are elements that are used to connect geometry as they area a useful geometric entity in FE. They are useful for spot and seam welds, adhesive, bolts. Connectors are often comprehended from geometric bodies into several unique solver defined formats. Connectors store their position, joining allies, connecting rulebooks and realizing categories. They will be manually generated, engrossed from connections or trade in.

Altair (Hypermorph) tool is the useful solution which offers interactive and parametrical change to the profile of a model. The different tactic offers quick contour changes on mesh changing webbing quality. It also allows to create contour variables that can be used for scheme accuracy during morphing. Altair (Batch mesher) tool of Altair is used to generate high quality mesh in fastest way for outsized assemblages. By curtailing labour intensive meshing tasks, this auto meshing expertise offers added phase for value added skilled simulation undertakings.

Modified octree method of mesh refinement is use to satisfy the Delaunay condition. In order to get rid of less primitive elements the modified octree is made use of in this component. The octants present in the enclosed cube of the 3D domain is refined until the boundary conditions and internal important quantities are approximated, most of which is carried out at the edge and midpoints. Care is taken to develop structured grid pattern of mesh at the Lug hole for better convergence and higher resolution. The connectivity over such structures is regular. For the problems were bending is dominant and accepted the use of mid-side tetrahedron elements provide best fitting solution. As the stated problem requires a sufficient stiffness to transfer the load to the structure the meshing is done using the tetrahedron elements.

V. STRUCTUTAL OPTIMISATION

Sub case specific response is considered and enhanced with response to various force in case of geometry / topology optimization. Not constrained to limited load oriented results but develop results describing shrink and growth as it is also product based. The output files of supported H3d format used and enhances response time and quality in post processing. Can be utilized to study composites and their behaviour from the response to loading conditions. Various types of response are available on being resultant force in sections. Shell elements for volume (enclosed) is utilized. Tapered beams are included along with mesh refinement and re doing auto with smoothing function. Altair Inspire helps to visualize the concept of development process by providing suitable structural details for parts and assemblies. ST. Inspire provides for quick and efficient investigation into concepts by design engineers, product designers and architects. This reduces overall investment and product detail. The new version is updated with state of art technology.

From basic model extra mass is added for finding the proper load path during optimization. The part is divided into design and non-design space. The design space includes the part of the basic model where extra mass was added. Since the boss is attached to the engine bearing and the base is attached to the bulkhead they are selected as design space for optimization. The non -design space includes the extruded portion of the lug where the loads are acted upon as well as the base portion of the bracket where the bracket containing the 3cm diameter holes where component is fastened to bulkheads by means of fasteners. Region between the boss and the base is not attached to any member, hence it is selected as design space.

The base is full constrained for translational movement and rotational movement for the purpose of analysis. The design space is where the optimization of the part is carried out and the software identifies the selected non-design space and interprets that there should be no optimization in the non-design space. The iteration of the mass target is set to 10% of the manufacturing constraint. The bracket is analysed for stress and displacement by reducing it to 10% of its original weight. The results from the analysis are compared for strength and stiffness with baseline bracket to arrive at the optimized design space for weight reduction.

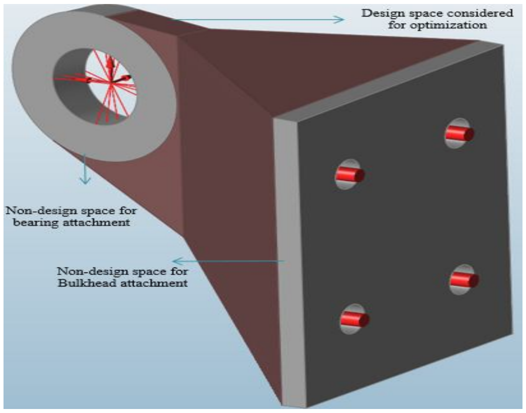
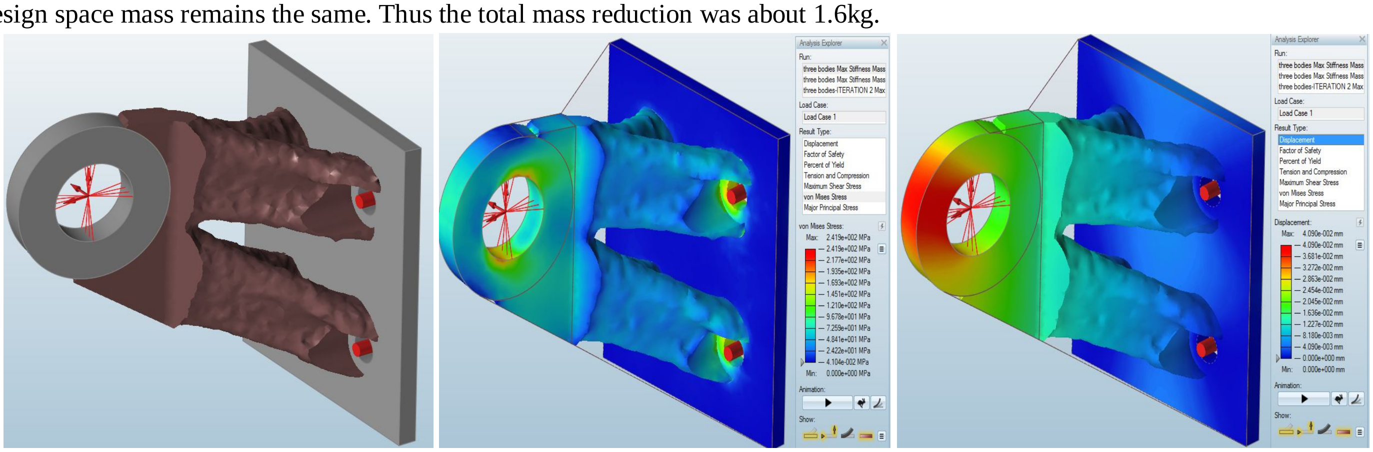


Fig 10 : Extra mass added to the base part

Defining the design and non-design space is required as a start for the process of optimisation. Simplify the model by disfeaturing using solid edit / simplify patch tool. Apply material properties to the design and the non-design space. Apply loads, boundary conditions, constraints from loads and support panels. Click on the list load cases under loads /supports & sort the loads & support approximately. Click on the shape control panel Apply symmetry and draw direction. From the pull down menu click on view >property editor>click on design region from browser. Uncheck auto function and enter min. and max. Element size manually Setting CPU and working directory from the pull down menu Click on edit >preference >optimization>set number of CPU and run the history path Optimization setup click on optimization panel > run optimization >setup stiffness /stress base solution > run. Design explorations / click on >show optimization >results and move the shape explorer slider to understand the different stages of shape generation Validate setup click on analyses button under the explorer to evaluate the shape generated CAD generation – click on FIT to generate the CAD geometry of shape generated.

The topology shape optimization achieved in INSPIRE is in accordance with the load path of the given loads and boundary conditions The load path is from the point of the application of the load to the points on the support (bolter region of the bracket with the bulkhead).The optimized topology cannot be used directly for manufacturing but can be applied through 3D printing. Thus during optimization, the NX part with extra mass having a total mass of 2.6734Kg with design space of 2.2162 Kg and non-design space of 0.457199Kg. The optimization was run at 20% of mass as first iteration with maximum stiffness as objective and the design space is optimized. The result of which is the design space is reduced in mass to 0.6361kg and the total mass to 1.0608Kg. The non-design space mass remains the same. Thus the total mass reduction was about 1.6kg.



Optimised design space Von – Mises plot Displacement plot

Figure 11: Iteration 1 with no manufacture constrain and mass target as 30%

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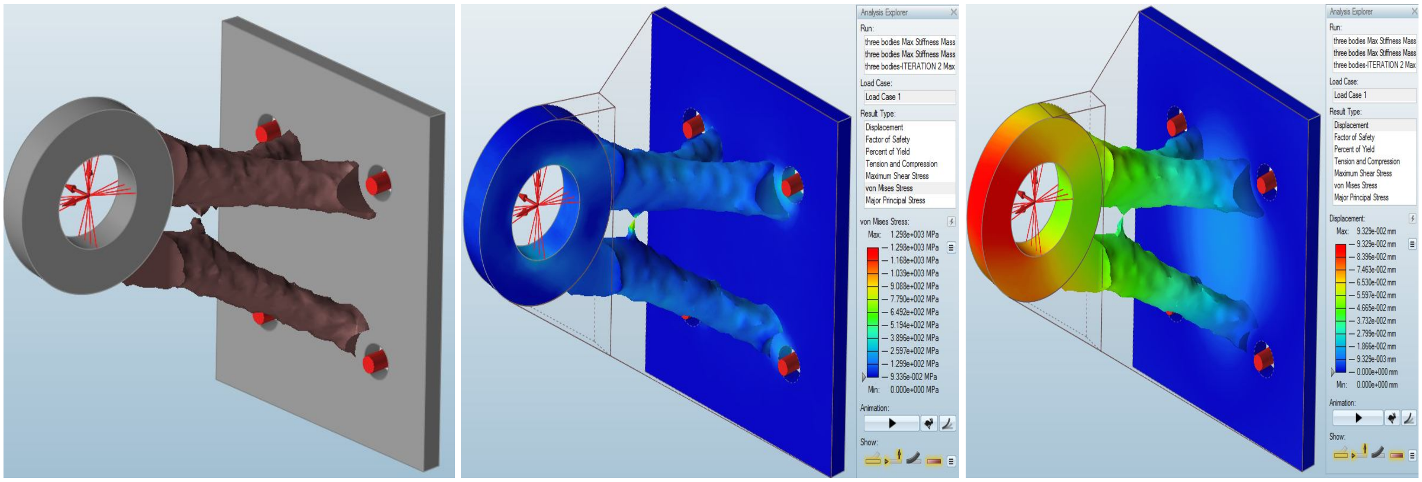
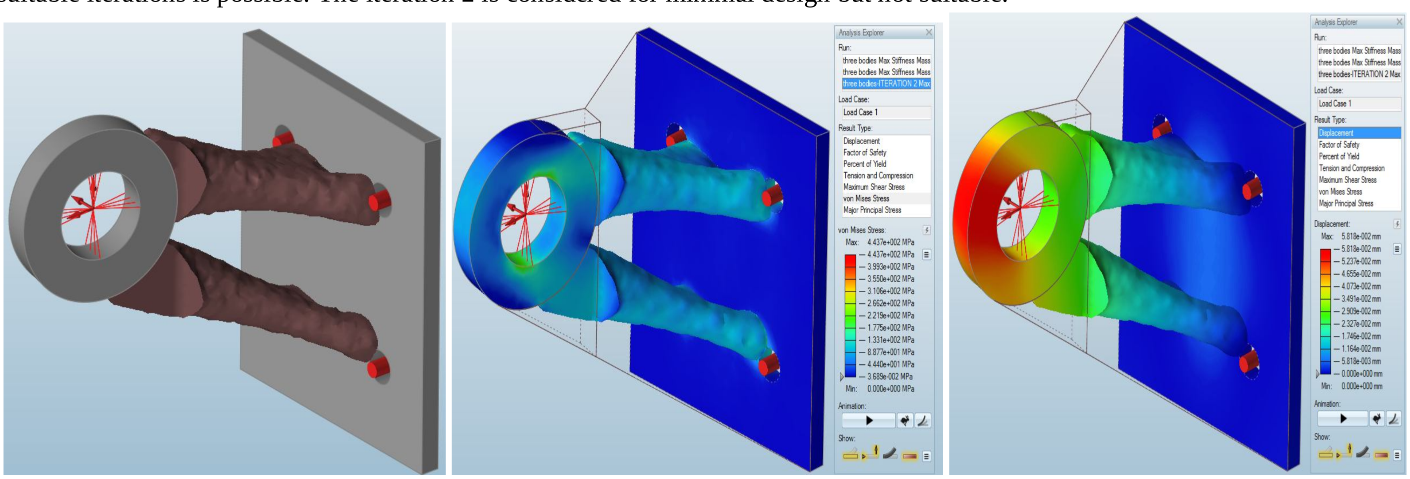
The weight of the optimised design space for the iteration 1 is 0.251Kg and the resultant of the Von-mises stress for maximum is 241.9 Mpa with the corresponding displacement as 0.041mm.Hence further iteration must be carried out and optimum of two more iterations are possible.



Optimised design space Von – Mises plot Displacement plot

Figure 12: Iteration 2 with no manufacture constrain and mass target as 10%

The weight of the optimised design space for the iteration 2 is 0.073Kg and the resultant of the Von-mises stress for maximum is 649.2 Mpa with the corresponding displacement as 0.093 mm.Hence further iteration must be carried out and optimum of one more suitable iterations is possible. The iteration 2 is considered for minimal design but not suitable.



Optimised design space Von – Mises plot Displacement plot

Figure 12: Iteration 2 with no manufacture constrain and mass target as 10%

The weight of the optimised design space for the iteration 3 is 0.1288Kg and the resultant of the Von-mises stress for maximum is 443.7 Mpa with the corresponding displacement as 0.058 mm.Hence this iteration is considered most suitable as the optimum stress and displacement is obtained .The design is further worked on using polynurb for redesign with strength consideration. The redesign is considered by adding suitable strength components like ribs and stiffeners for withstanding the target load.

VI. RESULTS AND CONCLUSION

As an inference from inspire analysis suggests that the topology optimized by Inspire is in accordance with the load path for the given boundary condition. The Load path for the given problem is from the point of application of load to the points of supports (bolted region of the bracket) .The optimized topology cannot be used directly for manufacturing as it is difficult to produce by conventional methods (Machining).The topology also doesn't cater for the space required for attachment of bolts on the base plate. But this optimized topology can be used as the basis for modeling the producible part with a similar load path.

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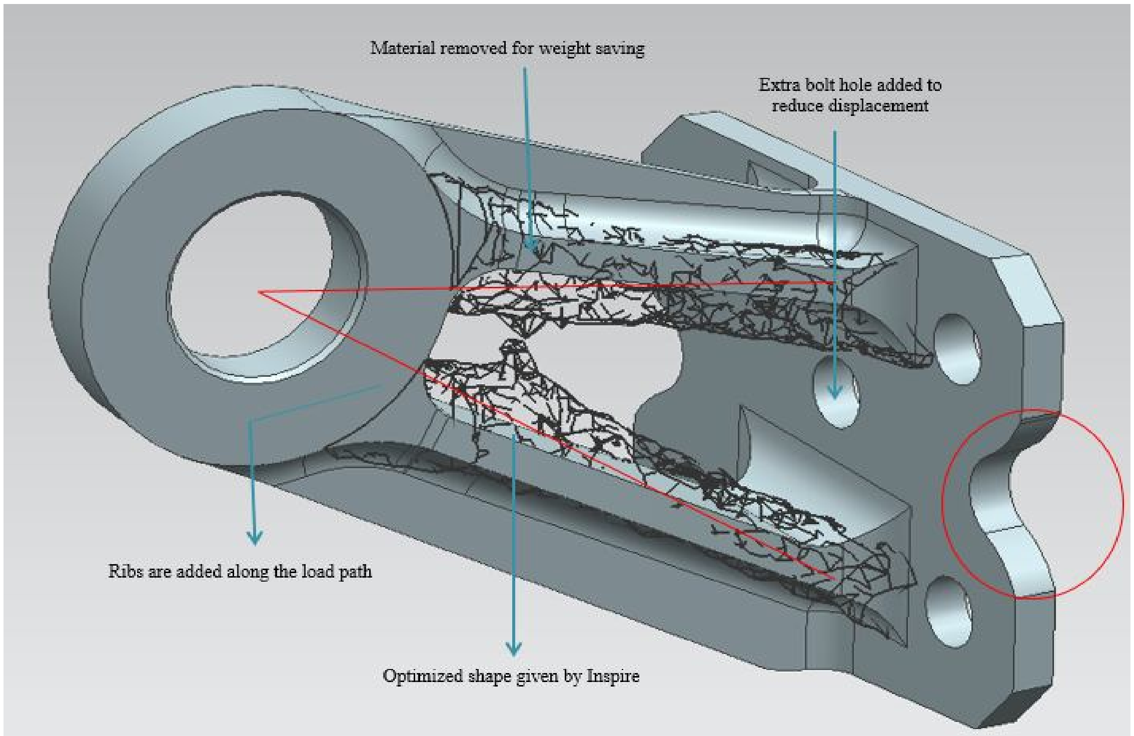
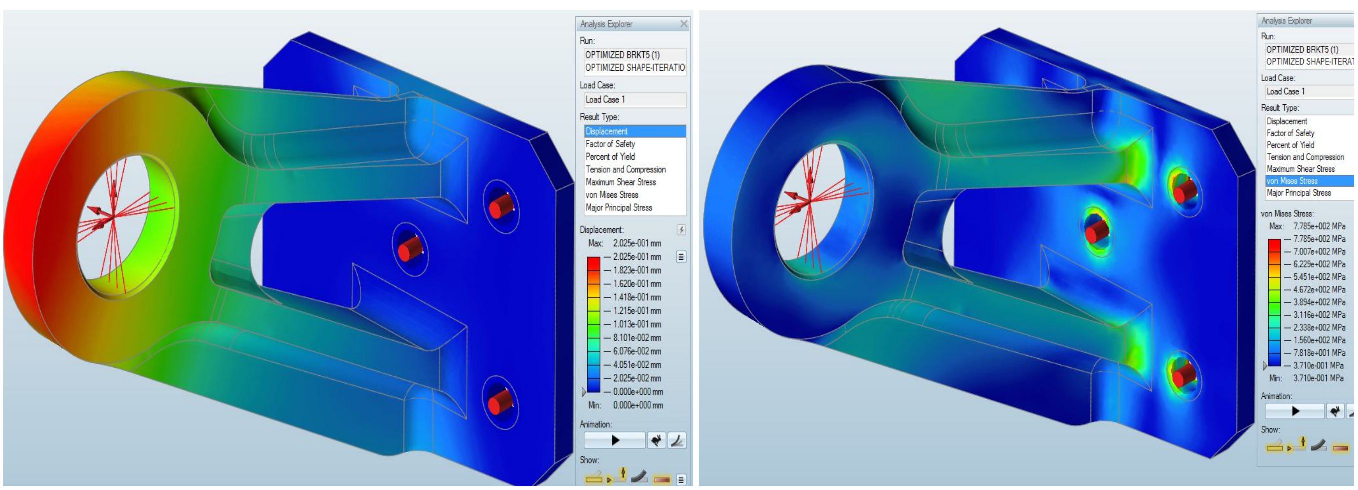


Fig 13: Part Modeled Based On Optimized Topology For Machining

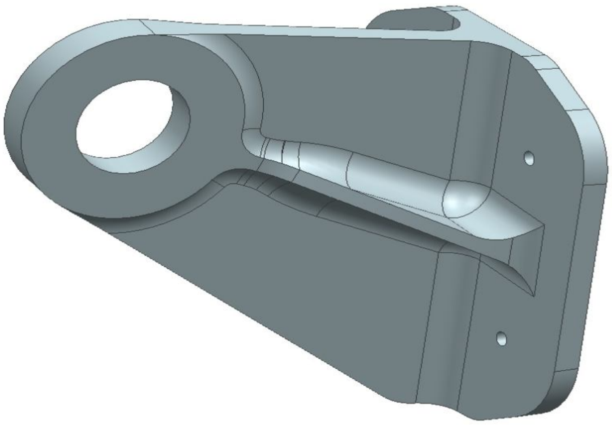


Displacement Plot

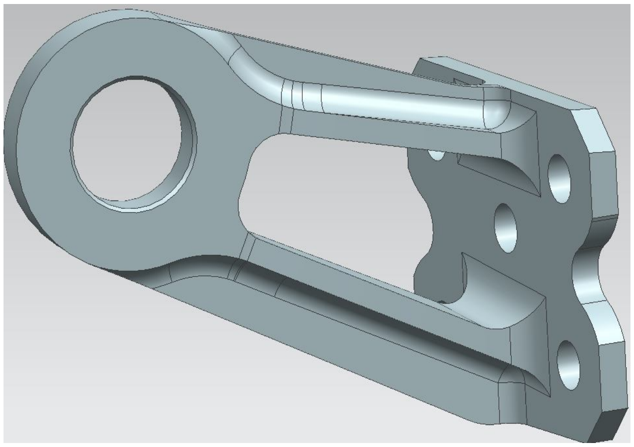
Von – mises Plot

Fig 14: Analysis in INSPIRE

From the analysis in Solid Thinking Inspire the result for maximum Von mises is 789 Mpa and the maximum displacement is 0.233 mm which is considered to be within the limit of safety for the operation of the component. These values are well within the material data hence are approved. Thus the use of iterative method has given satisfactory results with possible design solution and this form using polynurb gives a same reference environment as of the natural structure. FEA evaluate the strength of the structure. As there were only little variation in the solution the latter is said to be 'converged'. The material which is not required to bear the given load is removed for weight reduction thus creating a region of design envelope through which the load is transferred into the considered volume effectively. The FEA analysis is performed on the new design under the same load conditions. The elements are given weighting and the low scored elements are removed leaving behind the elements for which the constrains are stress, strain energy, etc.



Initial model



Optimised model

Fig 15: Comparison between the optimised and the bracket considered.

By comparison it is noticed that a weight saving of approximately 38% is achieved with no compromise in the structural strength of the material. The initial model weighing 0.434Kg is reduced to 0.268Kg.

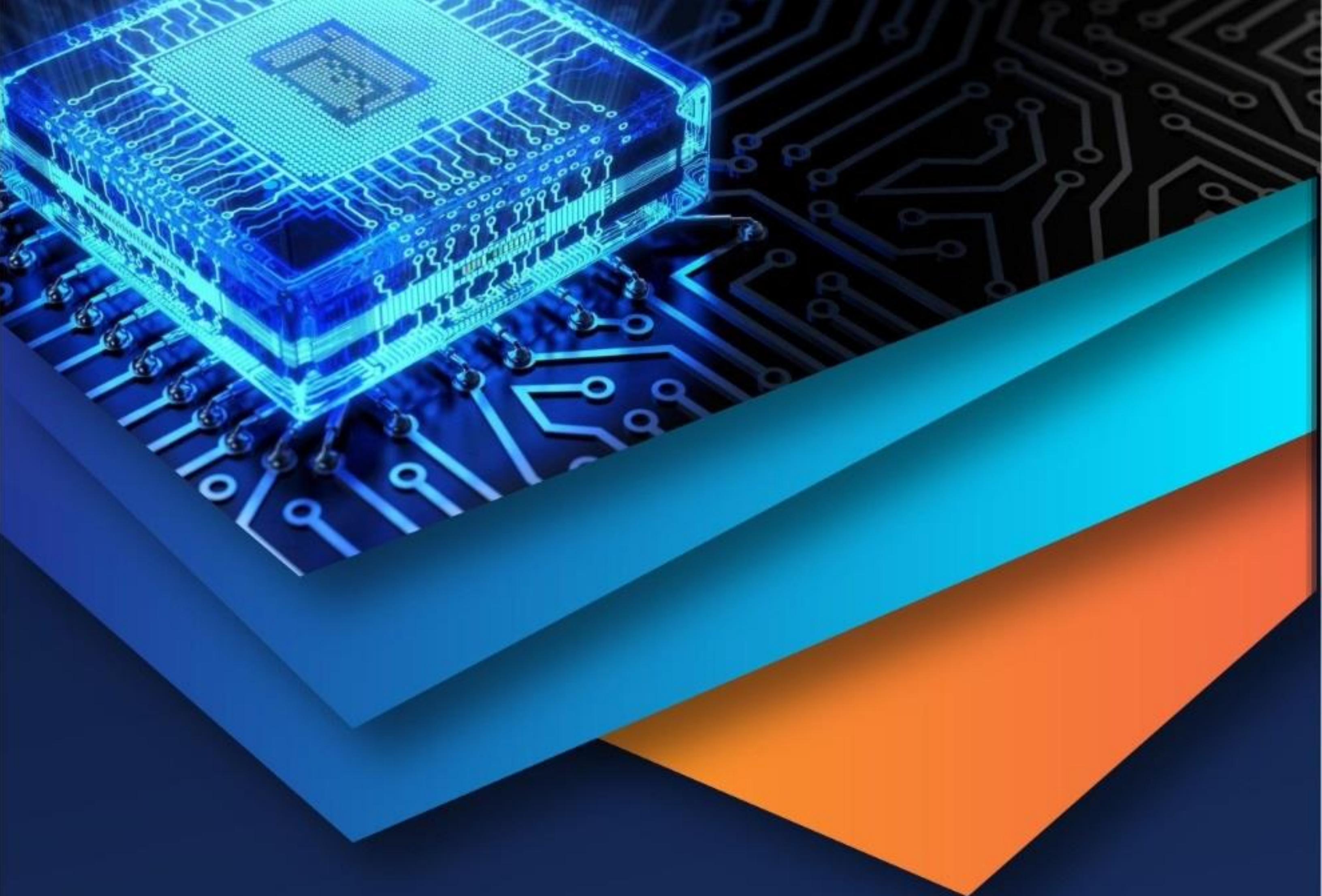
VII. CONCLUSION

A. Below Accompanying Ends are Observed

1) The Weight saving achieved on the above bracket is 0.166Kg, similar scheme can be implemented to other three brackets supporting the engine truss members.
2) Overall weight saving achieved by implementing this optimization scheme to other brackets is around 1Kg.'Inspire' is used as a software for topology optimization at the preliminary level for the designers.
3) 'Inspire' aids us to visualize the load path for any given structural problem and helps us take modeling decisions based on that.
4) Future updates in 'Inspire' should cater for analysis of assemblies and thickness optimization of sheet metal parts as they are very important for aerospace design.
5) Reduction of weight helps in reducing the carbon footprint and improves fuel efficiency.
6) Improvement in flight performance is observed in terms of acceleration, stiffness and strength.

REFERENCE

[1] Bharath Kenchappa, Lokamanya Chikmath, Bhagavatula Dattaguru, 2019
[2] A study on prognostic analysis of attachment lugs under off-axis loading, International.
[3] G S WANG, 1994 "Stress analysis for a lug under various conditions" Volume: 29 issue: 1, page(s): 7-16, Issue published: January 1, 1994
[4] M. A. Melcon and F. M. Hoblit,1953 Product Engineering Development in the Analysis of Lugs and Shear Pins, "Development in the Analysis of Lugs and Shear Pins" Volume 24, Number 6, pages 160-170, June 1953
[5] Sahil Naghate and Sandeep Patil (2012) "Modal Analysis of Engine Mounting Bracket Using FEA", International Journal of Engineering Research and Applications (IJERA), Vol. 2 ,1973 - 1979
[6] K. Kathiresan, T.M. Hsu, and J.L. Rudd. "Stress and Fracture Analysis of Tapered Attachment Lugs", Fracture Mechanics: Fifteenth Symposium. ASTM STP 833, R.J. Sanford, Ed. American Society for Testing and Materials, Philadelphia, 1984.
[7] Fokker, 2016 Fokker technical handbook for strength data: Elastic stress concentration factors, 2016. TH 3.281
[8] J. Schijve.1972 Fatigue in Lugs. Contributions to the Theory of Aircraft Structures. Professor A. van der Neut Anniversary Volume.9-Wolters Noord Hoff University Press



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