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"TOPOLOGY OPTIMIZATION OF A WING SPAR"

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ABSTRACT

The present fixed wing airplane industry is like never before in need for greatness to endure a profoundly powerful and cutthroat commercial center. As the outcome more redid plan and designs are offered and should be assessed .This work targets examining the wing fight design of a delta wing warrior airplane. The principal point of this task is to plan, upgrade and examine the wing fight of a contender fly airplane and we foresee the pressure because of applied loads. The plan boundaries are appropriately chosen and planned utilizing the CATIAV5 programming, and ANSYS programming. The work is expected to concentrate on the way of behaving of primarily advanced wing fight. The Underlying improvement is finished utilizing ANSYS.

Nomenclature

ANSYS-Analysis system, CATIA-Computer Aided Design Three-Dimensional Interactive Application, NACA-National Advisory Community for Aeronautics.

1. INTRODUCTION

In recent years, structural and optimizations have drawn increased attention for their contributions to design improvement, particularly in the early stages of product development. Weight of the structure has always been significant in the sector of manufacturing aircraft. Only 20% of a fully loaded modern subsonic aircraft's overall weight is released during takeoff, payload is. About half of the remaining 80 percent are aircraft, the weight of the gasoline makes up half of the empty weight. Thus, any reduction in structural weight may result in an increase. in the cargo Ultimately, for a particular payload, reducing aircraft costs, reduced fuel requirements result from weight. Consequently, it is not unexpected that aero plane makers are willing to invest significantly in weight loss. Consequently, an aircraft's primary goal to be a design engineer

1.2 TOPOLOGY OPTIMIZATION

The goal of topology advancement is to decide openings and network of the construction by adding and eliminating material in the drawn out space which is an enormous fixed area that should contain the entire construction not set in stone. In this way, a material model should be characterized to permit the material to accept middle of the road property estimations by characterizing an element of a persistent boundary. At all weight and execution plan of airplane and aviation designs, estimating and shape advancements are two conventional procedures and have been generally utilized. Topology enhancement has been created astoundingly throughout the course of recent a long time in both theoretical studies and useful applications. By rearranging the material design and likewise the heap conveying ways, topology enhancement has been perceived as one of the most encouraging methods in the plan of airplane and aviation structures. In the meantime, a lot of specialized difficulties featured in the quick advancement of air transportation and aviation primary designing advance the advancement of topology enhancement theories thus. Writing reviews have summed up later advances and uses of topology improvement. These outstanding accomplishments keep on persuading further investigations on the utilizations of topology advancement in planning convoluted designing designs.

2. OBJECTIVES

- To model an aircraft wing spar using CATIA V5
- Structural analyses on the modeled spar for the given loads and boundary conditions using ANSYS.
- Structural optimization of the modeled conventional wing spar using ANSYS.
- Stress analysis of the optimized wing spar.¬

3. METHODOLOGY

- Collection of data for selected aircraft
- Design parameters are estimated from collected data.
- The model of wing spar is created using CATIA V5 as per calculations
- A model of wing structure is imported into ANSYS¬ Workbench for analysis.

4. SOFTWARES USED

4.1 CATIA V-5

CATIA (PC supported three-layered intuitive application) is a multiplatform software suite for computer aided plan (CAD), PC helped fabricating (CAM), PC helped designing (CAE), PLM and 3D, created by the French organization Dassault Systems. Since it upholds numerous phases of item improvement from conceptualization, plan and designing to assembling, it is viewed as a CAD-software and is now and then alluded to as a 3D Product Lifecycle Management software suite. Like a large portion of its opposition it works with cooperative designing through a coordinated cloud administration and have backing to be utilized across disciplines including surfacing and shape plan, electrical, liquid and electronic frameworks plan, mechanical designing and frameworks designing.

4.2ANSYS WORKBENCH

This present reality happens at the same time. To approve your plan thoughts, you want tests that give genuine situations. Furthermore, in this present reality, material science doesn't alternate. The Ansys Workbench stage allows you to incorporate information across designing reproductions to make more exact models all the more effectively. Ansys Workbench makes it simpler to make more educated plan decisions by organizing all your reproduction information in one place. Ansys offers primary analysis software arrangements that empower designers of all levels and foundations to address complex primary designing issues quicker and that's only the tip of the iceberg productively. With our set-up of tools, architects can perform limited component examinations (FEA), customize and automate answers for primary mechanics challenges and examine various plan situations. By utilizing our software right off the bat in the plan cycle, organizations can save costs, lessen the quantity of plan cycles also, put up items for sale to the public quicker.

5. DESIGN, MODELING AND ANALYSIS

5.1 DESIGN SPECIFICATIONS

In this undertaking we have taken Euro-contender Typhoon detail connected with plan. The Euro-contender Typhoon is an European twin-engine, canard delta wing, multirole warrior. The Typhoon was planned originally as an air predominance warrior and is made by a consortium of Airbus, BAE Systems and Leonardo that leads most of the venture through a joint holding organization. The Euro-contender is a superior presentation warrior airplane for use in both air safeguard and in the air attack job. The Euro-warrior is a multi-job battle airplane of the most recent age. Through its capacity to organize driven tasks, there is a nearby relationship with its own air, land and maritime powers as well likewise with those pre-owned military partners .In activity guarantees unrivaled adequacy of the weapon framework for air battle and degree to bigger distances (past visual reach) to safeguard its own powers and assets and increase the requirement of the connected air tasks.

- Root Chord = 8220mm
- Tip Chord = 1030mm
- Semi Span Length = 5450mm
- Front spar = 25% of chord
- Thickness of web at root = 20mm
- Thickness of flange at root = 80mm
- Height of flange at root = 16mm
- Thickness of web at tip = 10mm
- Thickness of flange at tip = 40mm

5.2 LOAD CALCULATION

- ➢ Lift Load Factor = 9g
- ➢ Takeoff weight = 23.500KN
- ➢ Factor of Safety = 1.5
- ➢ Limit Load = Takeoff weight x Lift load = 23.500 9.81×9 Limit Load = 2074.815KN
- ➢ Design Load = Limit Load
- ➢ Factor of Safety = 2074.815×1.5
- ➢ Design Load = 3112.222KN
- ➢ Load on Semi Span = Design load/2 = 3112.222/2
- ➢ Load on Semi Span = 1556.111KN
- ➢ Pressure over Wing = Load on Semi Span/ Semi
- ➢ Exposed Area = 1556.111/25.6
- ➢ Pressure over Wing = 60.785KN/mm²

5.3 LOAD DISTRIBUTIONS ON SPAR

SHEAR FORCE CALCULATIONS AT SECTIONS

Area of trapezoidal section A1 = 0.5 x h x (L1+Ltip) = 0.5 x 545 x (1749+1030) = 727277.5mm2

Pressure over wing =Load on Semi Span/Semi exposed area = 60.785KN/mm2

Shear Force = Pressure Load x Area = 46.031 KN

BENDING MOMENT CALCULATIONS AT SECTIONS

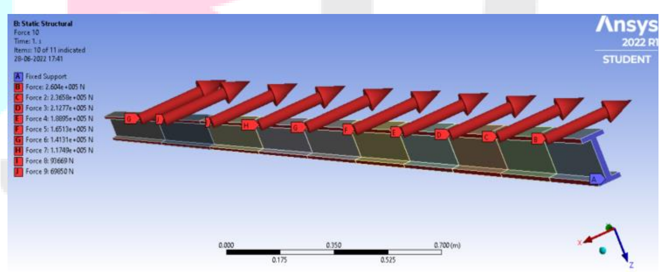
Centre of Gravity of trapezoid section = (((h/3) x ((Ltip+2L1)/(Ltip+L1))) = (((545/3) x ((1030+2x1749)/(1030+1749)))= 296.000

Bending Moment = Shear Force x C.G = 46.031 x 296.000 = 13625.385 KN-mm

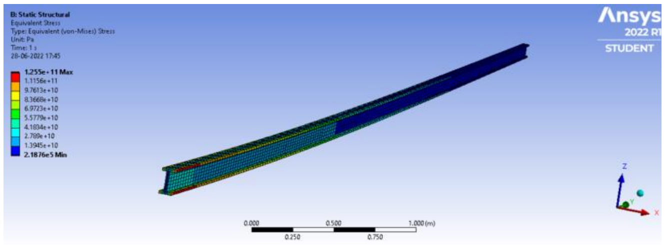
Chord	Moments (KN-mm)	Shear Force (KN)	Moments on each spar (KN)
Tip	0	0	0
1	13625.385	46.031	6812.692
2	20116.100	69.850	10058.05
3	26606.815	93.669	13303.40
4	33097.530	117.488	16548.76
5	39588.160	141.307	19794.08
6	46078.690	165.127	23039.48
7	52569.675	188.946	26284.83
8	59060.390	212.765	29530.19
9	65551.105	236.584	32775.55
Root	72041.820	260.403	36020.91

5.4 BOUNDARY CONDITIONS

In this analysis, the spar is considered a cantilever beam where one end is fixed where the degree of freedom is restricted in all six directions and another end is left free.



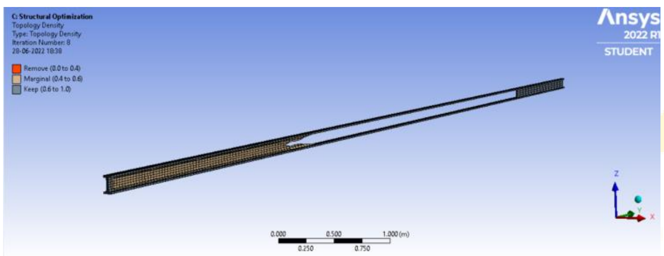
5.5 STATIC ANALYSIS



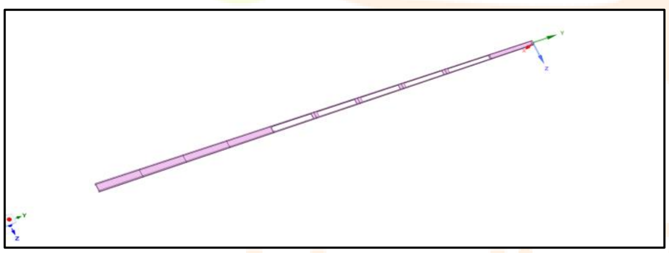
Von Misses Stress Distribution of Spar

5.6 TOPOLOGY OPTIMIZATION

Initially the boundary conditions will be given to the spar structure where the region to be optimized will be selected and other regions will be excluded. The objective given here was to reduce mass by about 70% and the topology density is displayed.

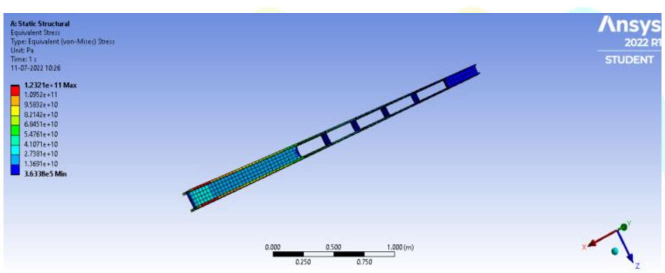


This optimized model is then exported to ANSYS Space claim and for refining and smooth finishing and supports was given to enable structural strength.



Optimized model

5.7 STATIC ANALYSIS



Von Misses Stress Distribution

6. FUTURE SCOPE

- Design optimization of the spar may be conducted by considering other loads.
- Design optimization of the spar using different materials.

7. RESULTS

After meshing, the spar is then taken to post processing using ANSYS. The results are then obtained after post processing was done on both conventional and optimized spar.

	Before Optimization	After Optimization
Weight of the Spar	63.67 Kg	51.431

- The spar initially weighed 63.67 Kg and was reduced to 51.431 Kg.
- 19% of the total weight of the spar was¬ reduced.

8. CONCLUSION

This work was carried out for spar..The Spar with the finalized geometry was modeled in CATIA V5. Static Structural analysis of the spar was done in Ansys Workbench. Design Optimization of the spar was obtained using ANSYS. Comparative study of spar before optimization and after optimization was done and concluded that a weight reduction of 19% is achieved.

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