

# International Journal of Innovative Research in Science, Engineering and Technology

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## Design Analysis of Air Craft Wing RIB

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**ABSTRACT:** This work displays the advancement of a parameterized robotized generic model for the basic plan of a aircraft wing. Besides, with a specific end goal to perform finite element analysis on the aircraft wing geometry, the system of finite element (mesh) period is robotized. Aircraft applied outline is characteristically a multi-disciplinary plan prepare which includes an expansive number of orders and skill. In this postulation work, it is examined how top of the line CAD software's can be utilized as a part of the early phases of a aircraft configuration prepare, particularly for the outline of an aircraft wing and its basic substances wing fights (spars) and wing ribs.

The generic model that is produced in such manner can computerize the procedure of creation and change of the aircraft wing geometry in light of a progression of parameters which characterize the geometrical qualities of wing boards, wing fights and wing ribs. Two diverse methodologies are utilized for the production of the generic model of a aircraft wing which are "Learning Pattern" and "Power Copy with Visual Basic Scripting" utilizing the PRO-E software. An execution examination of the bland wing model in view of these two methodologies is additionally performed. In the early phases of the aircraft configuration handle, a gauge of the auxiliary normal for the air ship wing is alluring for which a surface static investigation is more reasonable. In such manner, the procedure of finite element work era for the generic wing model is robotized. The finite element work is produced for the wing boards, wingspans and wing ribs. Besides, the finite element work is refreshed in view of any adjustments in geometry and the state of the wing boards and guarantee that all the work components are dependably legitimately associated at the hubs. The robotized FE work produced can be utilized for playing out the auxiliary examination on a aircraft wing.

### I.INTRODUCTION

Aggressive weight targets and shortened development time-scales in the civil aircraft industry naturally calls for an integration of advanced computer aided optimization methods into the overall component design process. Airbus has in a number of recent studies used ANSYS topology, sizing and shape optimization tools in an attempt to achieve lighter and more efficient component designs. Finite element based topology, measuring and shape improvement devices are commonly utilized as a major aspect of a two-stage design process. Firstly, a topology streamlining is performed to acquire a first view on an optimal configuration for the structure – an underlying outline with ideal load paths. Next, the suggested configuration is interpreted to form an engineering design and this design is then optimized using detailed sizing and shape optimization methods with real design requirements. Numerous examples from the automotive industry have demonstrated the ability of such an approach to quickly generate optimum components for stiffness, stress and vibration designs. This paper concentrates the utilization of Altair's finite element based topology, estimating and shape streamlining devices for plan of airplane segments. Aircraft parts are frequently strength outlines and topology enhancement strategies still totally do not have the capacity to manage buckling criteria. The present work therefore uses the traditional compliance based topology optimization method to suggest an optimal design configuration, which is engineered to provide the design with some stability. Finally, a detailed sizing/shape optimization is performed including both stability and stress constraints.

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**Materials:** Most old aircrafts typically used wooden construction. The wooden construction used for the wing spars was mostly of spruce or ash, a laminated sheet of wood. However, since, these spars are made of wood, there are under deterioratory effects over time by different environment and biological conditions such as wet and dry conditions. Furthermore, insect infestation can seriously reduce the strength of these wooden spars. Metallic materials are also used as a common material for the wing spars with aluminum sheet metal one of the common choices as the material for wing spars. Metallic fatigue over time is one of the main causes of concern for the metallic spars. The composite material based spars have the advantage of providing good strength and leads to a reduction in weight.

## II. LITERATURE SURVEY

Bindu H.C, Muhammad MuhsinAli.H “Design and Analysis of a Typical wing Rib For Passenger Aircraft” International Journal of Innovative Research in Science, Engineering and Technology. Vol.2, Issue 4,(2013) was found that inserting the circular hole in the plate enhance the buckling strength of the plate. The buckling strength of the plate is increased as the number of holes increased. Meanwhile the von misses stress in the component keeps on increased as the number of holes increased. Inserting holes in the rib found out to be effective with weight reduction compared to the initial geometry. The maximum stress occurs around the holes and it is to be considered as the critical region in the later stages.

R. Das, R. Jones “Damage tolerance based design optimization of a fuel flow vent hole in an aircraft structure”, Journal of Structural Multidisciplinary Optimization, Volume: 38; Pg: 245–265 (2009) demonstrated the application of damage tolerance based optimization to investigate the shape optimization of a Fuel Flow Vent Hole (FFVH) located in the Wing Pivot Fitting of an F-111 aircraft. It is noteworthy that the presence of such ‘cutouts’ is common in engineering structures used in many industries such as rail, aerospace, naval, and mining. These ‘cutouts’ are typically used for lightening the structure or for providing passage for equipments and cooling. Hence, the methodologies outlined in this paper to optimize the cutout shape can be easily extended to durability based shape design in similar structures. The shape optimization of the vent hole was performed using the three basic design criteria relevant to damage tolerance design, viz, stress, residual strength, and fatigue life.

K. Kalita, S. Halder, “static analysis of transversely loaded Isotropic and Orthotropic plates with central cutout”, Journal of Institution of Engineers, India series, C Vol: 95; Issue 4; Pg: 347-358(2014) observed that maximum shear stress in all boundary conditions occurs at the cutout periphery. As expected in all cases, maximum deflection is seen near the cutout and decreases towards the constraints. The variation of SCF for all the plates, in general, is more in orthotropic plate as compared to isotropicplate. It is observed that SCF depends on elastic constants and hence differ from material to material. The induced stresses in all cases have been intentionally limited within the elastic range by selecting a suitable applied load.

S. Bairavi, Mr. Suresh balaji, Design and Stress Analysis of Aircraft Wing Rib with Various Cut Outs has done Computation of stresses of an aircraft wing rib structure due to presence of three types of cutouts such as circle, elliptical and rectangle due to Pressure force over the wing section and Comparison of stress concentration factor for circle, elliptical and rectangle cut out ribs with the help of ANSYS 14.

## III. MODELLING OF WING RIB

### **A. Generic Aircraft Structural Wing Model:**

The generic aircraft structural model is developed by knowledge pattern using EKL (Engineering Knowledge Language), Visual Basic scripting and geometry automation tools and features that are available in PRO-E software. The generative structural analysis and Advanced meshing tools workbenches available in PRO-E software are used to perform the structural analysis and automated mesh generation of complete aircraft wing geometry. The aircraft

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structural auxiliary wing model is comprised of various components whose number, shape and geometry can be changed by a scope of various parameters. The airplane wing model incorporates,

- Wing Panels
- Wing Spars
- Wing Ribs

### B. Modeling Procedure:

Specifically the surface model of the aircraft wing is designed to be used for the finite element analysis of an aircraft wing. The surface model includes only surfaces which represent the wing shape including spars and ribs. The surface model is chosen for the finite element analysis because it is faster to do a finite element analysis on a 2D surface rather than a 3D one. It is also easier to mesh a 2D surface than a 3D one and also it is computationally beneficial. In a calculated stage, it is additionally not important to complete an exceptionally exact finite element analysis for the aircraft wing. Along these lines, a 2D investigation will give adequate data to be helpful in the reasonable stage while sparing time and assets contrasted with an entire 3D FE analysis.

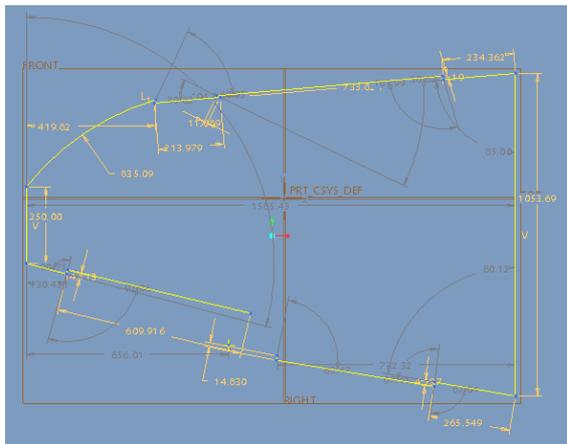
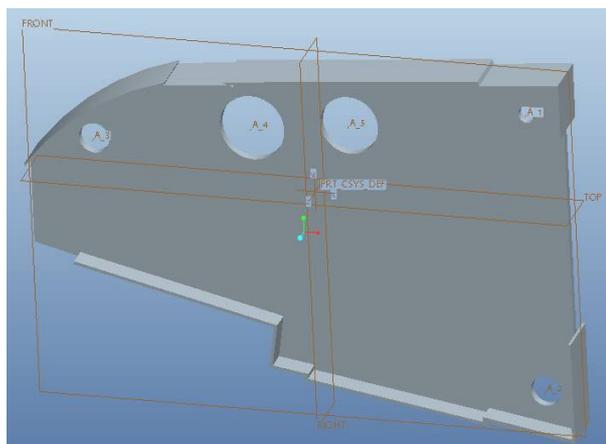


Fig 3.1 2D drawing Using PRO-E Software



figs 3.2 3D model is developed in PRO-E software

## IV. ANALYSIS OF WING RIB

### Material properties:

Table 1: material properties of Aluminium 2024-T3

Aluminium 2024-T3 material.	Values	Units
Young's modulus	71.7E3	Mpa
Density	2810	Kg/m <sup>3</sup>
Poissons ratio	0.33	
Ultimate tensile strength	520	Mpa

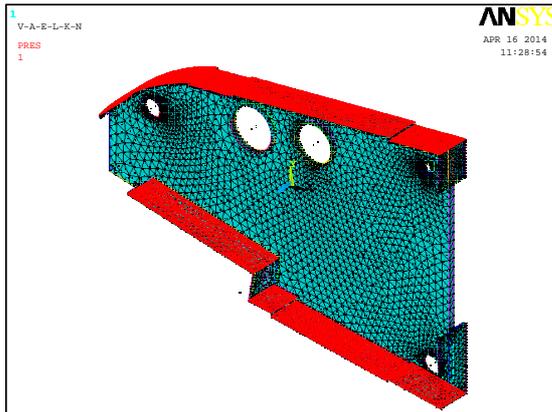


Fig 3.1 Loads applied on the base model of the rib

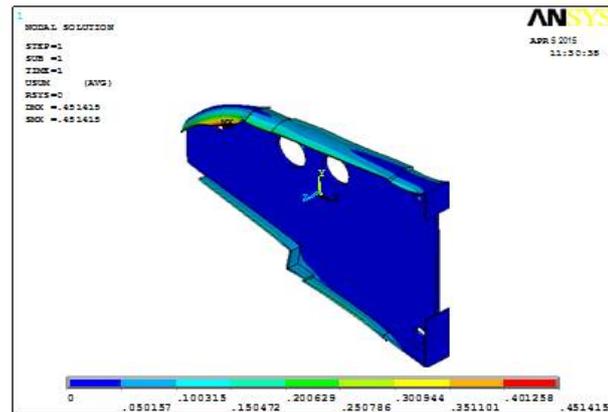


fig 4.2 Displacement vector sum of the base model of rib

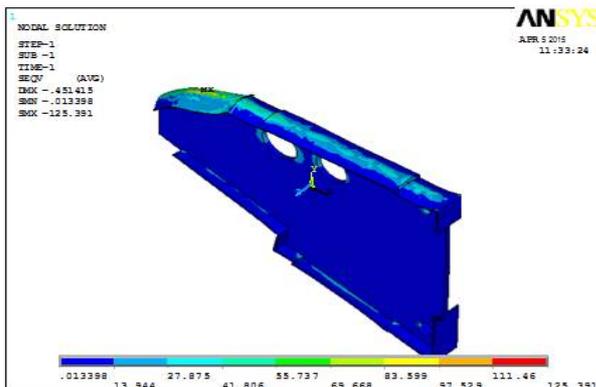


Fig 4.3 Von misses stress on the rib

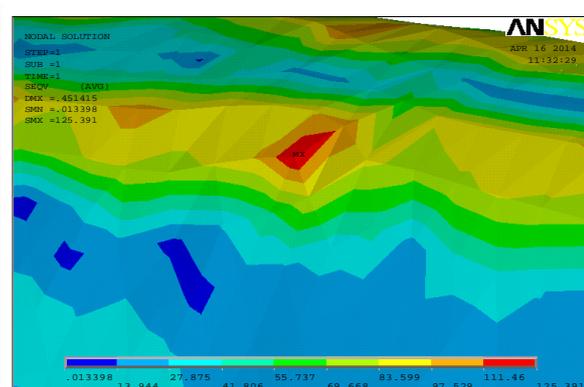


fig 4.4 Maximum Stress Area of the Base Model

#### A. BOUNDARY CONDITIONS OF THE BASE MODEL

The red color of the figure indicates the pressure acting on the outer portion of rib. Before applying the loads we have meshed the whole rib so the loads can be applied uniformly and the three circles at the corners of the rib are constrained

#### B. RE-DESIGN OF THE OPTIMIZED MODEL

Basic reference model is changed to the above design after applying the Optistruct application to that. Design changes had been generated in Ansys using unsmooth option. Allowing the width of the horizontal segments ( $w_1$  and  $w_2$ ) to vary would involve changing the shape of the cut-outs in the ribs, and design variables would have to be linked to ensure for example that the vertical stiffeners remained along the centerline of the truss-members. With the current shape optimization pre-processing tools for Optistruct this would have been time consuming to set up, and with the short time scales of the project this complexity was not implemented. Having constructed finite element models for detailed sizing and shape optimization, optimization was now performed designing for minimum mass with both manufacturing requirements and stress and buckling allowable as design criteria in the optimization process. For stress, a Von Mises stress allowable was used with a reduction factor for fatigue. For buckling, the outline theory was not to permit buckling of the structure beneath extreme burdens. The buckling imperatives for the improvement were characterized requiring the locking load calculate straight eigenvalue buckling to be greater than solidarity for every single extreme load. To avoid optimization convergence problems, due to buckling mode switching, buckling

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constraints were formulated for the five lowest buckling eigenvalue in each load case. The optimization as it stood converged to a feasible design for all thirteen ribs, with the final masses summing to a total close to the weight target specified for the work package.

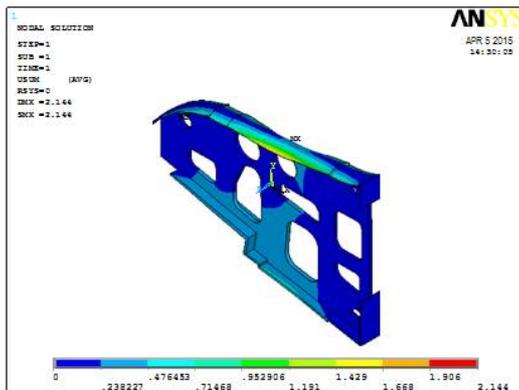


Fig 4.5 Displacement Vector Sum of optimized model

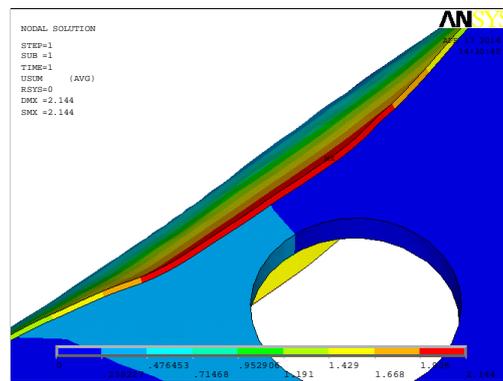


fig 4.6 Displacement Vector Sum Of The Optimized Model

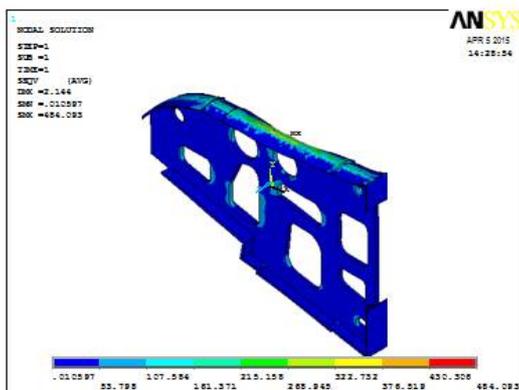


Fig 4.7 Von Misses Stress on the Optimized Model

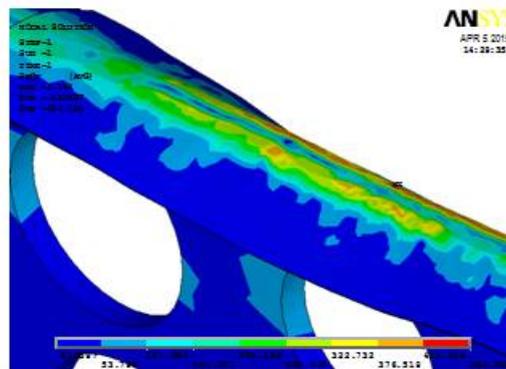


fig 4.8 Maximum Stress Area of the Base Model

### C. Final Design:

The maximum stress on the rib is 483.04Mpa at the top flange of rib which is under safe limit under the Hydrodynamic pressure of 8Mpa and minimum stress on the rib is 0.133Mpa

The critical portion of stresses on the rib is observed at the node of 2520 which is helpful to reduce the stresses by the thickness at that portion or changing material properties

The Above optimized model design is under the safe limit of the pressure 8 MPa. The ultimate tensile strength of Aluminium 2024-T3 material is 520 Mpa our analyzed stress is 483 MPa which is less than UTS

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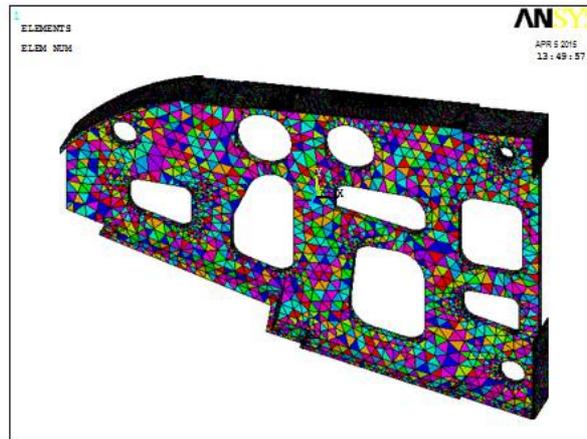


Fig 4.9 Final Design

## V. RESULTS AND DISCUSSION

### A. STRESS COMPARISON FOR TWO MODELS

Table 2 stress results

Contents	Base Model	Optimized Model
STRESS(Mpa)	490	484
DISPLACEMENT(mm)	0.451415	2.144
MASS(kg)	58	40

The above table shows the comparison of stress, displacements and mass of two models, which is below the yield point value of Aluminum 2024-T3 material (520MPa)

### B. COST ANALYSIS

Table 3 cost analysis

	MASS(Kg)	COST(Rs)
BASE MODEL	58	8700
OPTIMIZED MODEL	40	6000

From the above tables we came to the conclusion that the weight of the rib has been reduced and also the cost of the material is also reduced from stress comparison table we conclude that the stresses on the base model and also optimized model are similar by this we can conclude that the optimized model is safe

From the cost analysis table we can notice that the cost of the material is reduced by Rs8700.00 to Rs6000.00 now we have saved Rs1700/rib. In the wing of the airbus there are so many ribs if we reduce the weight of each rib then we can reduce the weight of whole wing by 40-50 %. As we reduce the weight of the each wing then we can reduce the weight of whole plane by 20-30 %.

## VI. CONCLUSIONS

The present work illustrates how topology, sizing and shape optimization tools may be used in the design of aircraft components. The technology has been successfully used in an industrial environment with short industrial time scales and has on a single application proved to be able to provide efficient stress and stability component designs.

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For airplane segment plan it is additionally vital to know about the effect of changing stacking circumstances. The truss sort plans got utilizing the topology advancements are exceptionally particular outlines improved for certain loading circumstances. Load definitions for the most part change as the plan of an airplane develop, and this could truly influence the optimality of the structure. It could in this way show crucial to decisively pick applications for topology streamlining and simply use the advancement on structures with especially described stacking (loading) conditions. The variety of weight is initiated in enhanced model contrasted with base model according to the necessity of underneath yield point stretch which is 325 MPa and also the variety of removal is instigated in improved model contrasted with base model which is lower than the 3 mm according to the prerequisite. As per the given requirement the reduction of weight is 16% decreased compared to reference model. Hence the cost analysis also reduces by using the base model and optimized model readings.

### FINAL RESULT:

Optistruct software was developed to produce an innovative rib design, which resulted in an optimized weight saving over 500kg per aircraft.

Wing Rib will sit in aircraft wing structure as shown in below figure

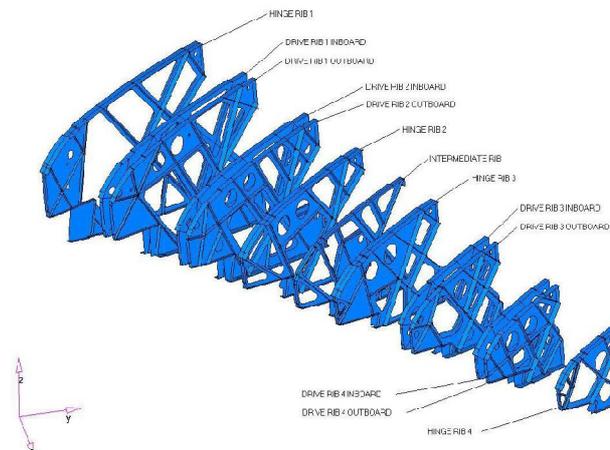


Fig 6.1 Wing Ribs will sit in to aircraft wing assemble

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