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A REVIEW ON DESIGN AND ANALYSIS OF RIBS

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Abstract — **Rib Maintaining the shape of wing and also support the bending and compressive loads which act on the wing .the objective is to increase the critical buckling strength and reduce the weight of the ribs. Linear static and buckling analysis and performed on the idealized configuration using FEM package. The optimum design parameter are suitably selected and then the model was designed in the CATIA software**

Keywords— **Aluminium alloy, Wing Rib, Modeling in CATIA V5, FEM analysis, Wing box, Skin-Stringer Panels, Maximum Shear Flow, Diagonal Tension, Incomplete Diagonal Tension, Design Optimizing (MOD), cutouts, stress concentration factor, stress analysis.**

I. INTRODUCTION

The aircraft is constructed primarily from thin metal skins which are capable of resisting in plane tension and shear loads but buckle under comparatively low values of in-plane compressive loads. For aerodynamic reasons the wing contours in the chord wise direction must be maintained without appreciable distortion. Therefore to hold the skin-stringer wing surface to contour shape internal structural support units are presented which are referred to as wing ribs. Taking into consideration various design and functional aspects, openings are provided in these ribs for access and maintenance of various purposes. In addition to the wing rib main function of maintaining the wing aerodynamic shape, the ribs also are presented for many other purposes that can be

1- Limiting the length of the stringers to an efficient column compressive strength which increases the skin-stringers stability under compressive loads.

2- Transferring and distribution loads

3- Redistributing shear forces at discontinuities in the wing

This rib need to be analyzed for stress values when discontinuities present inside it.

II. PROBLEM DEFINITION

In this paper the passenger aircraft wing rib with different cut outs are and considered for the detailed stress analysis. The wing structure consist number of ribs and box portion of one middle rib having I section is designed for analysis. Stress analysis of the rib with circular and elliptical cut out section is carried out to compute the stresses at ribs due to the applied pressure load.

The main objectives are:

- Computation of stresses of an aircraft wing rib structure due to presence of two one is circle and other is elliptical due to Pressure force over the wing section with the help of ANSYS.

- Comparison of stress concentration factor for circular and elliptical cut out ribs.

III. LITERATURE REVIEW

Bindu H.C, Muhammad Muhsin Ali. “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. Mean while 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 air-craft. 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 cut-out", 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 isotropic
plate. 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.

IV. DESIGNING PHASE

The designing is done by modeling software CATIA V5. There are two types of rib structure in my review paper with cut outs such as circle and elliptical. These two cutouts are designed for stress analysis purpose.

4.1 Designing of Rib structure with Circular holes:

The design length of rib structure is 750mm. It contains seven holes with varying diameters from 28mm to 55mm.

Figure 4.1 Modeling of rib structure with circular holes

4.2 Designing of Rib structure with Elliptical holes:

The design consists of totally seven elliptical holes with varying major diameter of 28 mm to 55 mm and minor diameter varying from 20 mm to 45 mm.

Figure 4.2 Modeling of rib structure with circular holes

V FINITE ELEMENT ANALYSIS

In this project ANSYS software is used as the pre-processor and postprocessor. The pre-processing task includes building the geometric model by importing it from CATIA V5 model of rib structure and extracting geometry, building the finite element model, giving these elements the correct material properties, setting the boundary conditions and loading conditions the structure is analyzed. Analysis is done in ANSYS solver phase. It solves the forces and reactions to get stresses. In the post processing stage, the results are evaluated and displayed. The result for above two models is tabulated from ANSYS software.

5.1 Analysis of rib structure:

AA 2024-T3 is used in current rib structure due to high strength and fatigue resistance properties. The model is imported from CATIA V5 to ANSYS to get stress values. After importing the model this has to be meshed, before applying the boundary condition and loading conditions.

TABLE 4.1 MATERIAL PROPERTIES

Density	**2770 kg/m³**
Compressive Yield Strength	**280 MPa**
Tensile Ultimate Strength	**310 MPa**
Young's Modulus	**71000 MPa**
Poisson's Ratio	**0.33**
Bulk Modulus	**69608 MPa**
Shear Modulus	**26692 MPa**

5.1.1 Meshing of rib structure with circular holes:

Meshing is the part of analyzing phase. Purpose of meshing is to divide the model into number of individual elements to find the stress distribution. Meshing of circular cut out model is shown in figure below.

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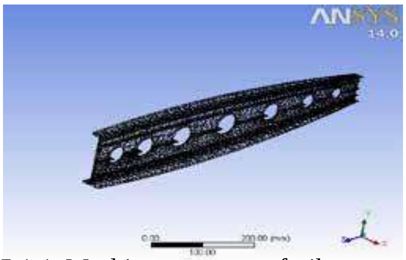

Figure 5.1.1 Meshing contour of rib structure with circular hole

5.1.2 Stress distribution of rib structure with circular holes:

Stress value is high near the cut section. As the load considered at the top portion the maximum stress field occurs in the top portion. The loading values are σ_Y = 75 MPa , σ_z = 100 MPa .

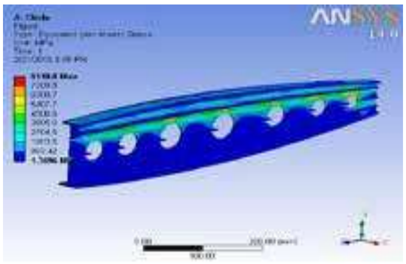

Figure 5.1.2 Stress contour of rib structure with circular holes

5.1.3 Meshing of rib with elliptical holes:

Purpose of meshing is to divide the model into number of individual elements to find the stress distribution. Meshing of elliptical cut out model is shown in figure below.

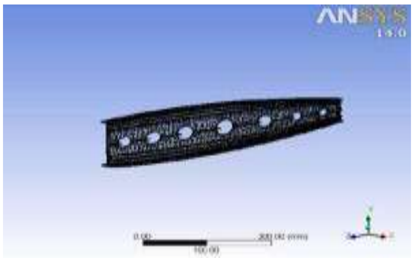

Figure 5.1.3 Meshing contour of rib with elliptical holes

5.1.4 Stress distribution of rib structure with elliptical holes:

Stress value is high near the elliptical cut out section. As the load considered at the top portion the maximum stress field occurs in the top portion. The loading conditions are same for all cut outs.

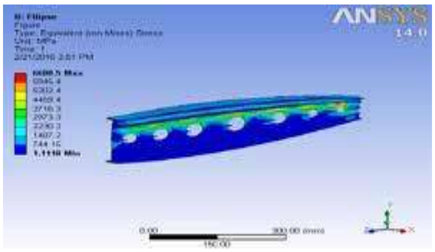

Figure 5.1.4 Stress contour of rib structure with elliptical hole

5.2. Comparison of Stress Results:

The Von mises stress distribution values from the ANSYS output is tabulated below for various cut out sections.

TABLE 5.2.1 STRESS VALUES FOR CUT OUTS

Circular	**Elliptical**
σ Max	**σ Max**
8110	**6600**
7209	**5945.4**
6308.7	**5202.4**
5407.7	**4459.4**
4506.6	**3716.3**
3605.6	**2973.3**
2704.5	**2230.2**
1803.5	**1487.2**
902.42	**744.15**

5.3. Determination of Stress concentration:

The stress concentration factor for static load can be determined as the relation of the actual maximum real stress in the discontinuity and the average stress, and is obtained through the equation (1).

$$\text{Stress concentration factor } K = \frac{Actualmaximumstress(\sigma_{max})}{Averagestress(\sigma_{nom})} \quad \text{------ (1)}$$

K Stress concentration factor

σ_{max} Actual maximum stress

σ_{nom} Average stress

Stress concentration factor is calculated based on above formula and the values are tabulated for circular and elliptical cutouts.

TABLE 5.3.2 VALUES OF STRESS CONCENTRATION FACTOR

K circular	K elliptical
0.8276	0.6735
0.8276	0.6825
0.8276	0.6825
0.8275	0.6824
0.8274	0.6823
0.8272	0.6822
0.8269	0.6819
0.8263	0.6814
0.8246	0.6800

- Elliptical holes may lead to high mesh refinement due to its shape
- Circular hole provides the gradual values of stress. The location of maximum stress concentration factor may vary under different condition

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