

Optimization of Aircraft Fuselage Bulkhead Structure Using Msc/Patran and Nastran Software

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ABSTRACT: The fuselage serves the purpose of accommodating cargo and passengers. Frames and bulkhead are located inside the fuselage. Bulkheads are used to redistribute the concentrated loads around structure such as wing, landing gear attachments and pressure boundary. In this project bulkhead are used to redistribute the concentrated load coming from the wing. The main aim is to reduce the weight of the bulkhead. Once the specific design is subjected for optimization and it is found safe. Finally we concluded that initially the design is of 34.5kg and optimize up to 20.69kg. So that reduces the weight by 13.81kg.

KEYWORDS: Aluminum alloy-2024 T351, fuselage Bulkhead, modeling in UGS NX, FEA analysis in Nastran and Patran.

I. INTRODUCTION

Aircraft structure may be divided into three basic parts fuselage, wing and empennage. The fuselage serves the purpose of accommodating cargo and passengers. Frames and bulkhead are located inside the fuselage. The vertical structural members are referred to as bulkheads, frames, and formers. The heavier vertical members are located at intervals to allow for concentrated loads. These members are also found at points where fittings are used to attach other units, such as the wings and stabilizers. Frames primarily serve to maintain the shape of the fuselage and to reduce the column length of the stringers in order to prevent general instability of the structure, whereas bulkhead are used to redistribute the concentrated loads around the structure such as wing, landing gear attachments and pressure boundary.

II. MATERIALS&METHODS

➤ There is no change in materials.

The project focuses on the optimization of the Aircraft fuselage Bulkhead structure by static analysis using Patran and Nastran software's. To carry out linear static stress analysis of aircraft bulkhead structure by FEM method by using the software MSC-NASTRAN & MSC-PATRAN. Compare the predicted maximum stresses under the given loading conditions against the material allowable stress values.

The main tasks in the FE analysis include:

- Generate finite element model by selecting compatible element type in UGS NX4.
- Carrying out the meshing of the model in PATRAN.
- Apply material properties to the different components in fuselage Bulkhead structure in PATRAN.
- Apply the boundary conditions to different components in fuselage Bulkhead structure in PATRAN.

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- Apply the loads through the lugs on frame structure
- Perform the finite element analysis by choosing appropriate solving methods in NASTRAN.
- Study and verify behaviour of the assembly under the given loads and boundary conditions in PATRAN.

1. UGS NX4

- Key benefits of UGS NX4 package
- UGS NX4 working with other integrated system like CAD/CAM and CAE application.
- Highly automated tool design.
- Maximizing productivity
- Based on the premises foundation
- Deriving business efficiency

2. MSC/PATRAN

A finite element pre and post processors (such as MSC/PATRAN) is a graphic based software package primarily designed to aid in the development of Finite Element Model (Pre processing) and to aid the display and interpretation of analysis results (Post processing). MSC/ PATRAN software is a mechanical computer aided engineering tool created for design engineers. Utilizing integrated automatic technologies MSC/PATRAN enables design engineers to build and modify solid models of computer parts and predicts their behaviour through design optimization. In addition pre-processing software helps the analyst modify the model if the result shows that changes and subsequent reanalysis are required. MSC-Patran is the world's maximum widely used pre/post-processing software for Finite Element Analysis (FEA), if solid modeling, meshing, analysis system and post-processing for many solvers together with MSC Nastran, Marc, Abaqus, LS-DYNA, ANSYS, and Pam-Crash.

3. MSC/NASTRAN

MSC/NASTRAN is a finite element analysis (FEA) program that was originally developed for NASA in the late 1960s under United States government funding for the Aerospace Industry. The MacNeal-Schwendler Corporation (MSC) was one of the principal and original developers of the public domain NASTRAN code. NASTRAN is the acronym of NASA Structural Analysis that is one of the popular general finite element programs of today. The potential users of MSC/NASTRAN include a majority of Aerospace industries, automobile manufacture, Universities, Research labs and many other industries.

4. LINEAR STATIC ANALYSIS

Linear static study signifies the most basic type of analysis. The word linear means that the computed response displacement or stress, for sample is linearly connected to the useful force. The term static means that the forces do not vary with time or, that the time difference is irrelevant and can so be safely ignored. A sample of a static force is a structure's dead load, which is included of the building's weight plus the weight of offices, equipment, and furniture.

III. FINITE ELEMENT ANALYSIS

Assumptions for FEA

- Accurate representation of complex geometry.
- Boundary conditions and loading are not restricted.
- Higher order elements may be implemented.
- Easy representation of the total solution.
- Model is easily refined for improved accuracy by varying element size & type.
- Time dependent and dynamic effects can be included.

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Material properties

Aluminum Alloy-2024 T351

- Young's modulus=70000 N/mm²
 - Density= 2800 kg/mm²
 - Poission's ratio= 0.3
 - Yield strength= 378 N/mm²
- Ultimate stress= 485 N/mm²

Load calculation for the wing fuselage lug joint

1. Aircraft category=medium size of fighter aircraft
2. Total weight of the aircraft=4500Kg=44145N
3. Load factor considered in design=6.
4. Centre of pressure (CP)=1500
5. Lift required for the aircraft=44145*6*9.81=397305N
6. Distribution of lift load on fuselage and wing= 20% and 80%
7. The load per wing=397305/2=198652.5N
8. Load of the wing along rear=198652.5*.8*.4=63568.8N
9. Moment=63568.8*1500=95353200 N-mm
10. The load on each lug =95353200/261= 365337.9 N

IV. RESULTS AND DISCUSSION

1. **Solid/CAD model of the fuselage Bulkhead:** The figure shows the three dimensional aircraft fuselage Bulkhead structure. Model is built using UGS NX4 software.

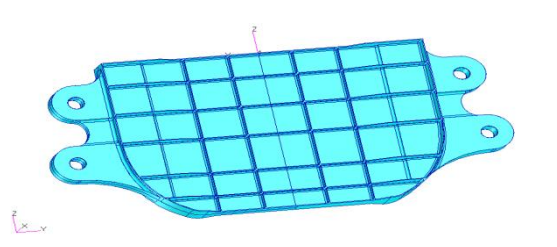


Figure 1.1 Design Model of fuselage Bulkhead

2. **FE model of fuselage Bulkhead:** The figure shows the FE model of fuselage Bulkhead. It is built using MSC/PATRAN software.

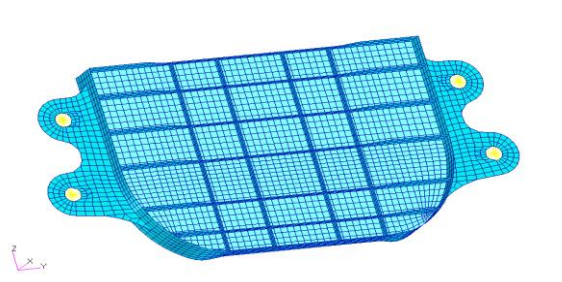


Figure 1.2: FE model

3 Load and Boundary conditions of fuselage Bulkhead: These conditions are for the part has applied which shown in below figures. Boundary condition is a method of applying load and constraining the part. Boundary and load conditions figures are shown below.here the side members are fixed in 1,3 directions and top and bottom surface is fixed in 1,2 directions.load applied is 365337.9N.

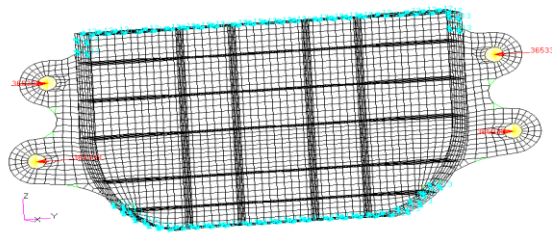


Figure 1.3 Boundary conditions for fuselage Bulkhead and applied loads on lugs

4 Displacement plot of fuselage Bulkhead: Figure 1.4 shows the displacement of the fuselage Bulkhead structure .when the loads is applied to the lugs , the maximum displacement observed is 1.13mm

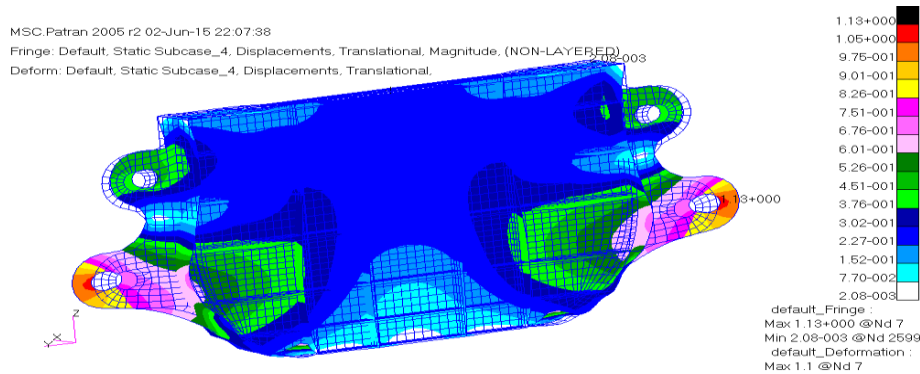


Figure 1.4 Displacement plot for fuselage Bulkhead

5. Stress tensor plot for fuselage Bulkhead: Figure 1.5 shows the Stress tensor (von misses stress) plot for fuselage Bulkhead structure. When the load 365337.9N is applied on each lug.

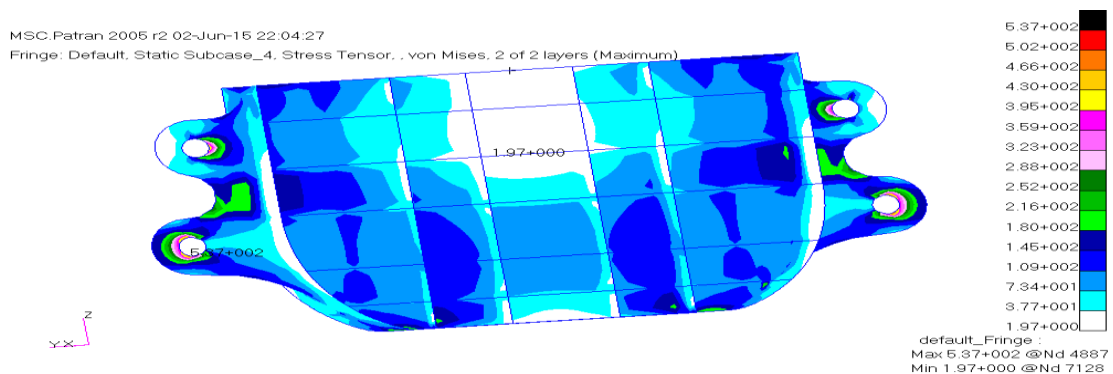


Figure1.5 Stress tensor plot for fuselage Bulkhead structure

5 Maximum and minimum principal stress plot for fuselage Bulkhead: Figures shows the Maximum and minimum principal stress developed on the fuselage Bulkhead structure. Maximum principal stress is $4.88e2 \text{ N/mm}^2$ and minimum principal stress is $-3.75e2 \text{ N/mm}^2$.

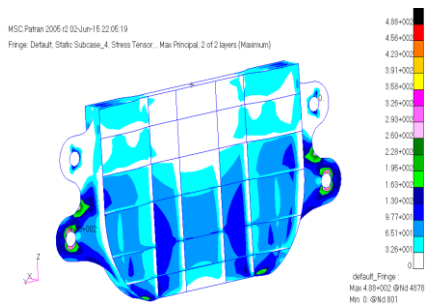


Figure 1.6 (a) Maximum principal stress

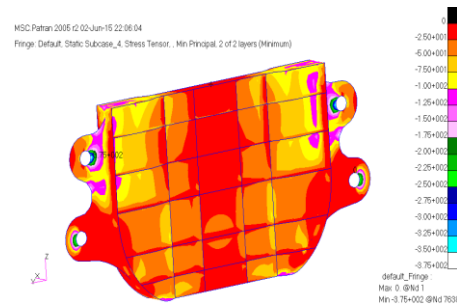


Figure 1.6 (a) Minimum principal stress

7. Maximum shear stress plot for fuselage Bulkhead: Figure 1.7 shows Maximum shear stress developed on the fuselage Bulkhead structure. Maximum shear stress is observed is $2.92e2 \text{ N/mm}^2$

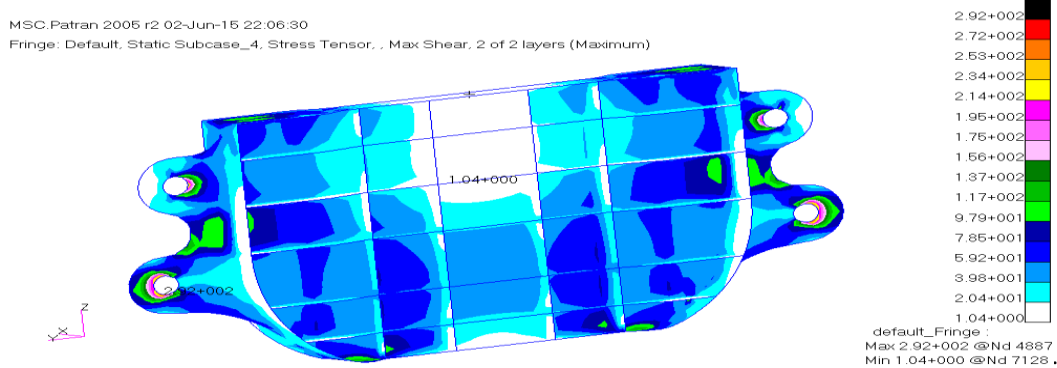


Figure 1.7 shows Maximum shear stress plot for fuselage Bulkhead structure

V. CONCLUSION

The results of initial and final design iteration show the more accurate result. So this is the best case identified with the optimization thickness. Here the stress tensor (von misses stress) increases as the thickness of the bulkhead structure decrease. The maximum Principal stresses reaches $4.88e2 \text{ N/mm}^2$ it is almost equal to ultimate strength of the material considered, at this weight of the frame is 20.69kg initially it was 34.5kg so the mass is reduced by 13.81kg. if we further decrease the thickness the stress will go beyond ultimate stress and the structure will fails,. The sections of the lug attachment are designed in such a way that they all must contribute the minimum weight.

VI. SCOPE OF FUTURE WORK

- In future, using different material for fuselage Bulkhead structure can be studied.
- In future, using composite material to reduce the weight and it can be studied for different analysis.
- In future optimize can be carried out for the load coming from the landing gear attachments.



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