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Design and Structural Analysis of Bracket for Control Unit in Light Combat Aircraft

Santosh S[a], Satish Kumar N[b], & Santhosh N[c]

[a]*UG Student, Dept. of Aeronautical Engineering, Nitte Meenakshi Institute of Technology, Karnataka, India.*
[b]*Senior Engineer, Research & Development, Buhler India Pvt Ltd, Karnataka, India.*
[c]*Asst. Prof, Department of Aeronautical Engineering, Nitte Meenakshi Institute of Technology.*

ABSTRACT

Every aircraft essentially consists of an Environmental Control System (ECS) which is very much required to control the interior environment for the flight crew and the equipment. The charged air (compressed air) from the 7th stage of compressor unit of engine is tapped & is used for cooling the cockpit and avionic system. The charged air is made to pass through the various components of the ECS such as pre-cooler, primary heat exchanger, secondary heat exchanger, cold air unit, condenser etc., thus, the charged air is converted to required temperature and pressure & is utilized for the cooling purpose.

In the current research paper, the design of control unit bracket locator for ECS is done with CATIA V5 R20. The structural analysis is very essential to ensure the concept that it can meet the requirements. We have furnished by using an analysis software package called ANSYS. The analysis by using ANSYS 14.5 packages gave us the desired results in the work undertaken by us.

The new design is done by using essential software, to reduce the prototype costing and bring out a conceptual design. For implementing any new design in an aircraft, the various analysis such as stress analysis, flow analysis and thermal analysis of the design are very essential. Since the design is a new concept and it has to withstand various loads and so there is a need to analyze it for different critical parameters.

Keywords *- Design, Prototype, Structural analysis, Bracket, Control unit, Light Combat Aircraft.*

1. INTRODUCTION

The control unit bracket used in Light Combat Aircraft has to fulfill all the functional requirements. The statement of our project confirms the optimized design and analysis of the component. Control unit is mounted on the rear fuselage in engine bay. It controls the PRV/SOV (Pressure regulating valve/Shut off valve) operation. It consists of servo pressure regulator to control the pressure regulating head and a solenoid to control the shut off head of the PRVSOV.

The solenoids are energized to open the SOV. The function of this control unit is to provide the datum regulation pressure for the pressure reducing head and servo supply to operate the shut off head of the PRVSOV. The servo air supply is taken from inlet of the PRVSOV for solenoid operation and from within the PRVSOV for the pressure regulation function. Henceforth, in our present work, a new methodology is developed to design bracket for control unit in light combat aircraft and analyze for its compatibility.

2. LITERATURE SURVEY

Michael Chun et. Al [1] Presented “Damage Tolerance of Aircraft Panels” which investigates Damage tolerance analysis and provided information about the effect of cracks on the strength of the structure. Damage tolerance evaluation must include a determination of the probable locations and modes of the damage due to fatigue, or accidental damage.

Santhosh N et. Al [2] have carried out extensive research on stress analysis of bracket used for engine mounting frame of an unmanned aerial vehicle, Further the research work investigated Static stress and fatigue analyses that have been done using CATIA V5 software. Static stress analysis has been done using NISA software. Aluminium 7075 T6 material which has high fatigue strength has been used in vertical stabilizer. From the static stress analysis, maximum principal stress value has been found out which is less than the yield strength of Al 7075 T6. The maximum principal stress value has been used in fatigue calculation and the obtained analytical result shows the safe number of factored fatigue life hours for the component. The result predicted in this work concludes the efficient number of factored fatigue life hours for the vertical stabilizer which would reduce the service cost of the component and ensures structural safety to the component.

Marcin Kurdelski et al. [3] investigated the bracket mounting frame which is idealized as a statically determinate structure and a stress analysis is performed using Strength of Material approach. The stresses developed because of loading on the structural members of the bracket mounting frame are calculated. A finite element model of the bracket mounting frame structure is developed and analyzed. The FEA stress and deformation results are compared with that obtained from "SOM" approach. Fatigue life to crack initiation is estimated for a critical lug of the landing gear unit by considering the constant amplitude landing cycles.

Goranson et al. [4] investigated the fatigue issues in aircraft maintenance and repairs, ensuring structural integrity of Boeing jet transports. Designing for continued structural integrity in the presence of damage such as fatigue or corrosion is an evolutionary process. His work focused on methods with special emphasis on practical fatigue reliability considerations. Durability evaluations are based on quantitative structural fatigue ratings which incorporate reliability considerations for test data reduction and fleet performance predictions. Fatigue damage detection assessments are based on detection reliability estimates coupled to damage growth and residual strength evaluations.

J.E Moon [5] investigated the Cumulative fatigue damage in lugs with and without interference-fit bushes. Fatigue tests have been carried out under constant and variable amplitude loading conditions and local stress measurements have been made using the Companion Specimen Method.

3. METHODOLOGY

1. The dimension of bracket for control unit in light combat aircraft is specified for drafting in CATIA V5 Software.
2. The bracket is modeled in CATIA V5 Software.
3. The CATIA model is exported and saved in IGES file format.
4. CATIA file is imported into ANSYS structural, to check the stress and displacement in the CONTROL UNIT BRACKET model.
5. After importing the model, the element type is given; element type is **ET**, **1, PLANE183.**
6. The geometry is meshed and the mesh is hexagonal with 6 nodes and associated 6 degrees of freedom. The mesh size is refined at the intricacies of circular profiles in the geometry considered.
7. Boundary conditions and material property are attributed to each member of the structure giving due considerations for the type of material used.
8. Loads are applied at required points with uniform distribution at brackets.
9. Post processing of the entire structure is carried out and the subsequent contour plots are obtained.

4. RESULTS AND DISCUSSIONS

The structure of the bracket is meshed with hexagonal mesh type having 6 nodes and associated 6 degrees of freedom. The automesh panel is a key meshing tool in ANSYS. Its meshing module allows you to specify and control element size, density, type, and node spacing, and perform quality checks before accepting the final mesh. A part can be meshed all at once or in portions. To mesh a part all at once, it may be advantageous to first perform geometry cleanup of the surfaces, which can be done in ANSYS.

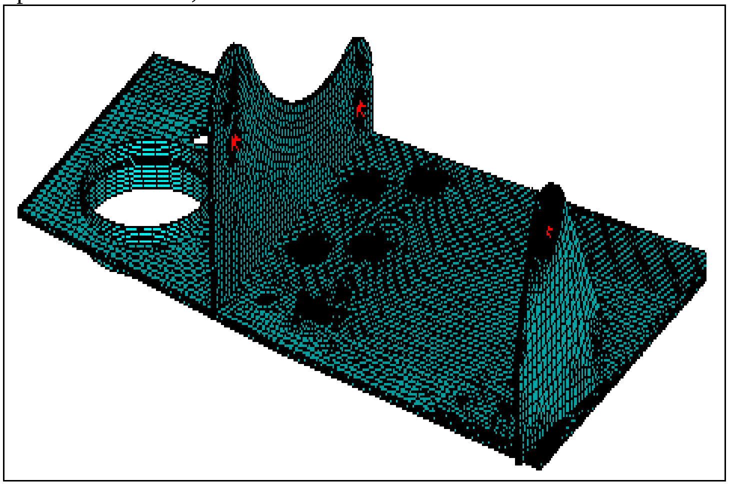

Fig 1: Meshing of Control Unit Bracket.

Loads of 490 N/mm^2 are applied at required points with uniform distribution at brackets in Uz direction.

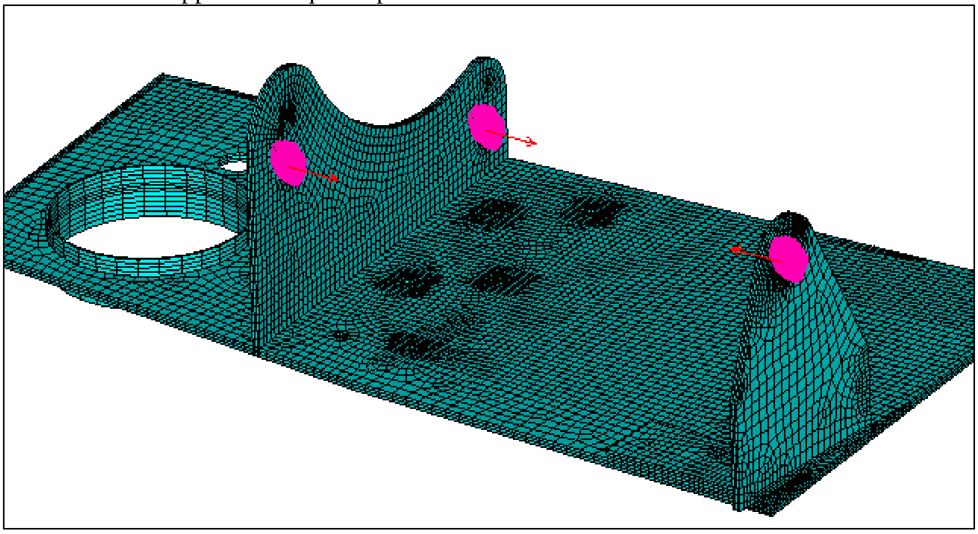

Fig 3: Load Conditions Acting on the Structure.

The stress over the plate is observed and contour plot is obtained for von mises stresses and displacement along Uz and Ux direction.

The value of tri-axial principal stresses varies from a minimum of 0.389E-03 to 32.8732 N/mm^2 while the equivalent von mises stresses varies from a minimum of 1.7122 Pa to a maximum of 485MPa.

The static structural displacement varies from a minimum of - 0.090797 m to a maximum 0.307454 m. The directional deformation along X axis varies from a minimum of -4.4272e-6 m to a maximum of 0.0002532 m.

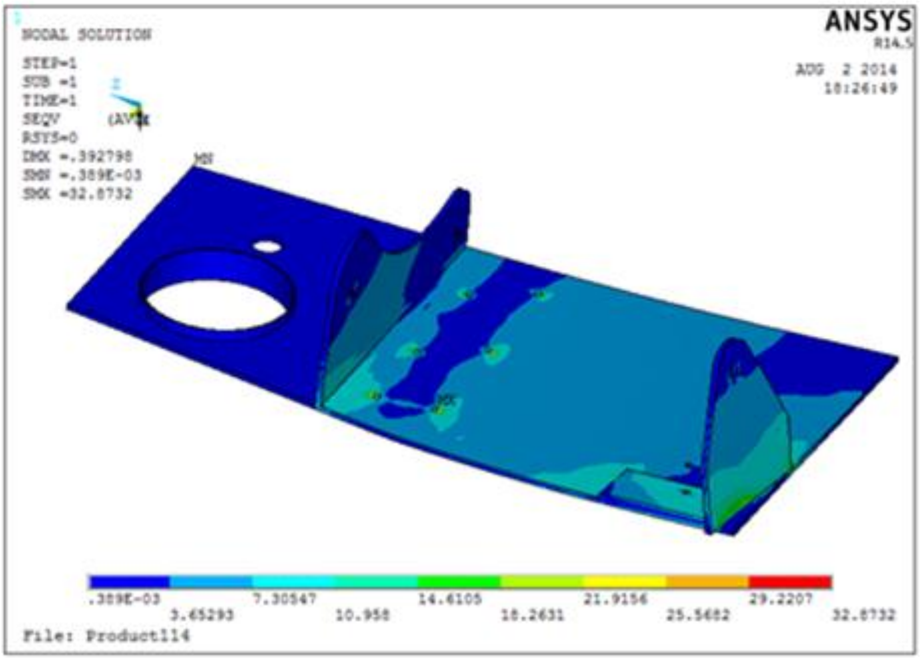

Fig 4: Contour Plot of the Tri-Axial Principal Stresses Acting on the Member.

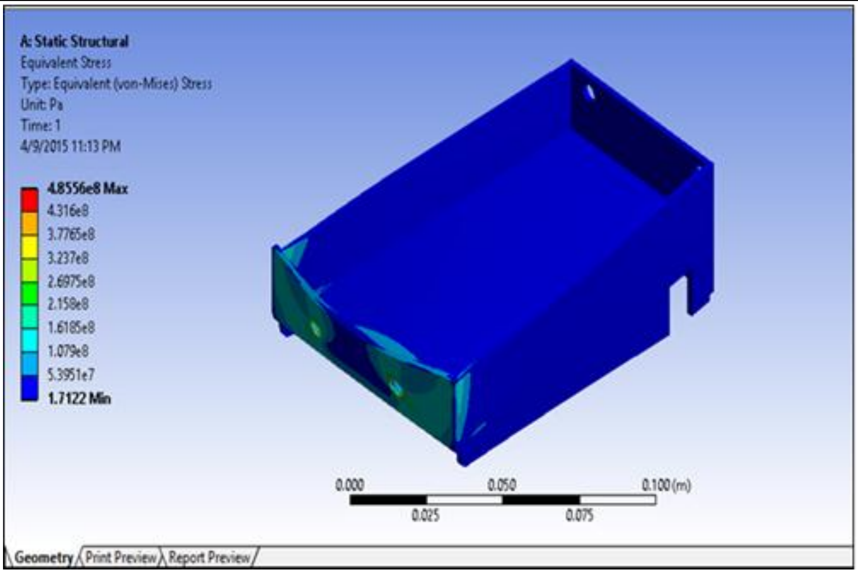

Fig 5: Contour Plot of the Equivalent von-Misses Stresses Acting on the Member.

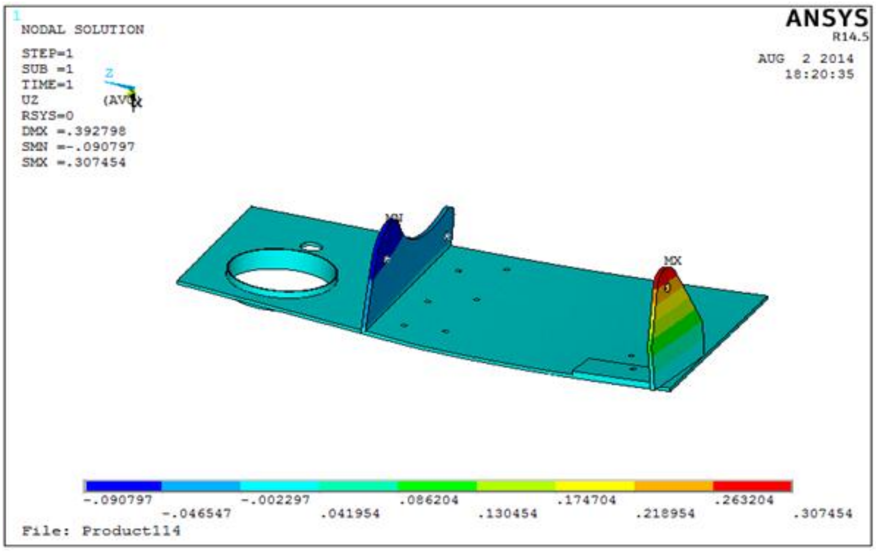

Fig 6: Contour Plot of Displacement along Z Direction.

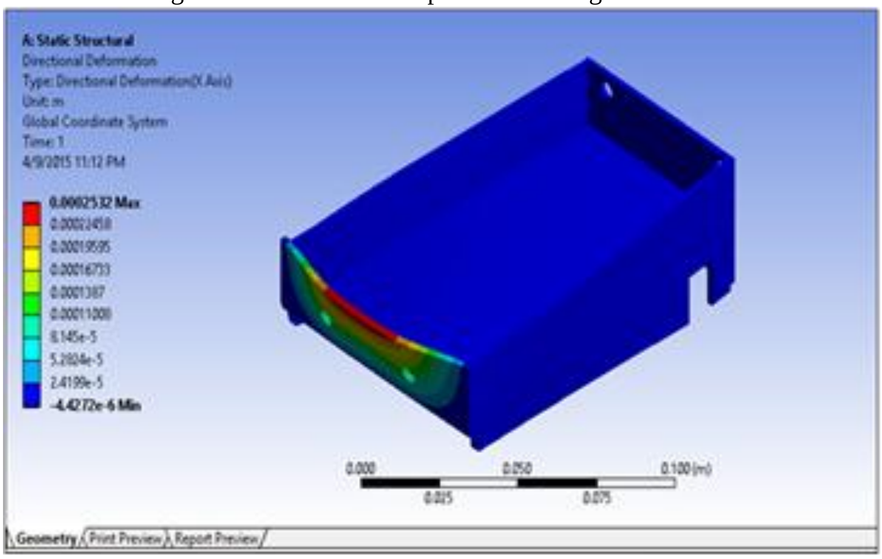

Fig 7: Contour plot of Directional Deformation along X Axis.

5. CONCLUSION

The main purpose of using the CONTROL UNIT bracket locator is to ease the installation of control unit; the installation of control unit is a very hectic task involving a lot of complexities. The whole process involved in the installation looks for the perfect location for mounting of control unit bracket, which not only causes stress concentration but also involves problems of directional deformation. All these aspects are to be taken care of before actual installation of bracket locator is completed.

The control unit bracket locator is mounted onto the aircraft and PRV/SOV is checked. With the help of this locator, the holes are drilled to fix the main bracket and this bracket locator is removed so that we can fix the control unit; the control unit is the "HEART OF THE ENVIRONMENTAL CONTROL SYSTEM" which provides air supply, thermal control and cabin pressurization for pilot.

The critical evaluation of the results give us a clear understanding of the tri-axial principal stresses, Von misses stresses, Displacement and Directional deformation, which helps us fabricate the CONTROL UNIT bracket locator providing fillets and internal recesses at critical regions where stress concentration is observed.

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REFERENCES

1. Michael Chun, Andrzej Leski, Krzysztof Dragan Air Force Institute of Technology, Warsaw, Poland "*Fatigue life analysis of main landing gear pull-rod of the fighter jet aircraft*", 28th International Congress of the Aeronautical Sciences, 2012.
2. Santhosh N, Dr N D Shivakumar, Chetan D M, Pooja Kumari, Sahana B C, Mahalya R, "*Design And Analysis of Engine Mounting Frame of An Unmanned Aerial Vehicle*", International Journal of Research in Aeronautical and Mechanical Engineering, Vol.2, Issue.5, May 2014. PP: 27-34, ISSN (Online): 2321-3051
3. Marcin Kurdelski Andrzej Leski Air Force Institute of Technology, Warsaw, Poland "*Crack growth analysis of the landing gear pull rod of the fighter jet aircraft*", Publisher: Institute of Aviation Scientific Publications, Review of Aeronautical Fatigue Investigations in Poland, May 2009-March 2011, 2011.
4. Goranson, Soon-Bok Lee, Seong-Gu Hong, "*Fatigue crack growth behavior of Al7050-T7451 attachment lugs under flight spectrum variation*", Publisher: Elsevier Science, Journal: Theoretical and Applied Fracture Mechanics, Volume: 40 Issue: 2 (2003-09) Page: 135-144. 2003.
5. J E Moon, U.G. Goranson, R.R. Merrill, "*Application of finite element analysis techniques for predicting crack propagation in lugs*". International Journal of Fatigue Volume 2, Issue 3, July 1980, Pages 121–129.
6. S. M. Beden, S. Abdullah, A.K Ariffin. "*Review of Fatigue Crack Propagation Models for Metallic components*" European Journal of Scientific Research, 28(3):364-397, 2009.
7. Jarkko Tikka and Patria, "*Fatigue life evaluation of critical locations in aircraft structures using virtual fatigue test*", International Congress of the Aeronautical Sciences 2002.
8. E. F. Bruhn, "*Analysis and design of flight structure*", 1973.
9. Michel-chun-yung niu, "*Aircraft structural design*", 1995. [10] Aerospace engineering / March 1996 "landing gear structural integrity".
10. J. C. σewman, Jr, "*Advances in fatigue and fracture mechanics analyses for aircraft structures*", Mechanics and Durability Branch, σASA Langley Research Center, Hampton, VA, USA.
11. Grigory I. σesterenko, "*Service life of airplane structures*", Central Aero hydrodynamic Institute (TsAGI), Russia, 2002.
12. C.M. Sonsino, *"Course of S-N curves especially in the high-cycle fatigue regime with regard to component design and safety"*, Int. J. of Fatigue 2007.