DESIGN AND STRUCTURAL ANALYSIS OF WING-FUSELAGE BRACKET OF A UAV

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ABSTRACT: An unmanned aerial vehicle (UAV), commonly known as a drone is an aircraft without a human pilot aboard. Wing bracket plays a major role in the transferring of loads from the wing structure to the fuselage. Bracket members secured respectively to the end of the wing at a forward or aft location, and to the aircraft fuselage form with a clevis pin a clevis connection with the clevis pin projecting through the bracket members. Especially in the UAV wing bracket need to transfer a high load, since the wing span of the aircraft is very high compared to the other. Here wing bracket is designed using CATIA software and then it is analyzed by using NASTRAN &PATRAN software. By analyzing, deflection and stress effects for the load acting on the wing-fuselage bracket can be determined easily. In this analysis piecewise approximation method is been used and for meshing tetra mesh is used.

Keywords: UAV, Bracket, Cam, Clevis.

1. INTRODUCTION

The continuous growth in air traffic has placed an increasing demand on the aerospace industry to manufacture aircraft at lower cost, while ensuring efficiency in operation, friendliness to the environment and high safety. To meet these objectives it is essential to consider the complete product life cycle including Development (e.g. Design), Manufacturing, Operation and Disposal.

The development and design of aircraft structures is a complex, multi-disciplinary exercise. For example, a typical short-range jet aircraft may be designed to reach a design service goal of approximately 50.000 flights. It can be derived easily that such aircraft will travel about 400.000 km / 250.000 miles on ground – only during take-off, landing and taxiing. Consequently, such aircraft will make more miles on ground than any conventional car! This example also illustrates the excessive loading history, which the structure has to withstand during its operational life, including many accidentally as well as operationally induced damages and cracks.

Within the last years, the development of aircraft structures has lead to a competition between composite and metallic structures. This competition has proved to be inspiring for composite technologies as well as for metallic technologies.

2. FUNCTION OF AIRCRAFT STRUCTURES

2.1 General

The structures of most flight vehicles are thin walled structures (shells). These resists applied loads i.e., aerodynamic loads that are acting on the wing structure. These structures provide the aerodynamic shape to the wing structures. And also these structures protects the contents from the outer environment conditions such as vibrations, dynamic loads etc.

2.2 Air Loads on Structural Components

a) Surface forces: Surface forces that acts on the surface of the structure. They are;
  – Aerodynamic pressure
  – Hydrostatic pressure
b) Body forces: Body forces that acts over volume of structure. They are;
  – Gravitation effects
  – Inertial effects

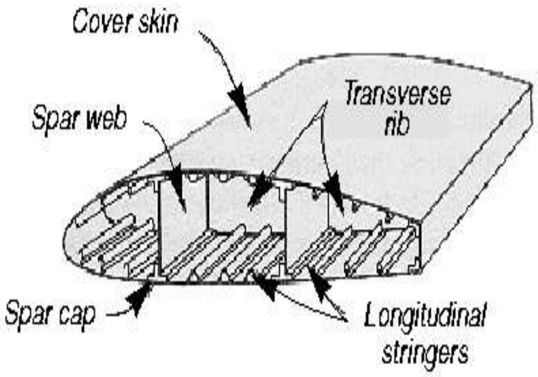

Fig.1. Figure showing the surfaces load action.

2.2.1 Action of Air Loads

All air loads are the resultant of pressure distribution over surface of the skin during, Steady flight, Maneuvers, Gust conditions

Air loads causes the following loads:
– Direct loads
– Bending, shear, torsion on parts
– Local normal loads on the skin

2.2.2 Aircraft Structural Loads

Before the structure can be designed, we need to determine the loads that will be imposed on the aircraft. Each part of the aircraft is subject to many different loads. In the final design of an aircraft structure, one might examine tens of thousands of loading conditions of which several hundred may be critical for some part of the airplane. In addition to the obvious loads such as wing bending moments due to aerodynamic lift, many other loads must be considered. These include items such as inertia relief, the weight and inertial forces that tend to reduce wing bending moments, landing loads and taxi-bump loads, pressurization cycles on the fuselage, local high pressures on floors, and many others.

These loads are predicted using Navier-Stokes computations, wind tunnel tests, and other simulations. Static and dynamic load tests on structural components are carried out to assure that the predicted strength can be achieved. The definition of strength requirements for commercial aircraft is specified in FAR Part 25 and this section deals with those requirements in more detail.

3. UNMANNED AERIAL VEHICLES

Fig.2. Figure showing a UAV

Over the past decade, and unmanned aerial vehicles (UAVs) have proven their worth in operations around the world. The Air Force and the Department of Defense are working to increase the capabilities of existing unmanned systems and to develop new systems with improved capabilities. To this end, Air Force efforts are consistent with the Air Force Concepts of Operations (CONOPS) and the Air Force Transformation Flight Plan.

Thus the designing the parts of the UAV take very important role. Each structural part should be able to withstand the loads. Mainly the wing-fuselage brackets should withstand the air loads and that should be transferred to the fuselage without any failure.

4. WING-FUSELAGE BRACKET

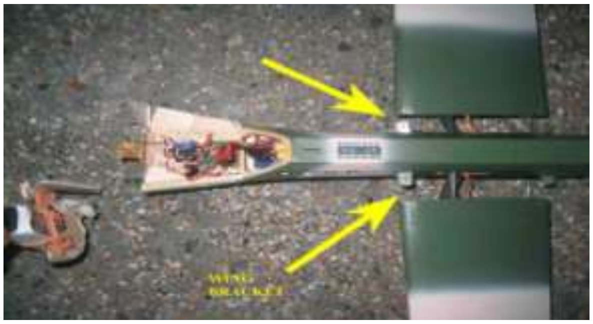

Fig.3. Figure showing a wing bracket of a UAV

Wing –fuselage attachment bracket is a structural member that attaches the wing to the fuselage. This bracket mainly carries the aerodynamic loads from the spars of the wing thus the bracket should withstand the stress acting on it. For a UAV the wing span is long and thus the load acting on the bracket will be high by considering its structural size. Bracket members secured respectively to the end of the wing at a forward or aft location, and to the aircraft fuselage form with a clevis pin a clevis connection with the clevis pin projecting through the bracket members. The pin bears integrally a first cam fitted within a circular opening of one bracket member. A pair of cam bushings rotatable mounted on the clevis pin to the side of the first cam is positioned within circular openings of dual ribs of the other bracket member forming the clevis connection. The cam bushings and the clevis pin are independently rotated to vary the angle of attack of the wing mounted to the fuselage and are locked at adjusted positions. Thus the bracket should be designed in such manner that it should be strong, resistant to vibration etc.

4. DESIGN OF THE WING BRACKET

In CATIA designing of model is done in sketcher of part designing. Using the tools the geometry of the bracket is designed according to the required dimensions. Mainly there are two ways to design the component.

- Extrusion of a 2D geometry
- Solid body pocketing

Extrusion of a 2D geometry

In this create a 2D model according to the selected view of the bracket. Either top view, side view or front view can be selected to create the 2D geometry. Then the geometry is extruded according to the dimensions. Some operations like trimming, edge preparations etc are done on the extruded geometry in order to get the required model of the bracket. Make sure that model is in the required shape and then constrain each parts of the geometry with respect to the axis system. Thus by using a 2D geometry we can convert a required 3D model.

Solid body pocketing

The second way to create a 3D model of the bracket is, solid body pocketing. In this a solid body or cube is created and pocketing is done on that to get the required bracket model

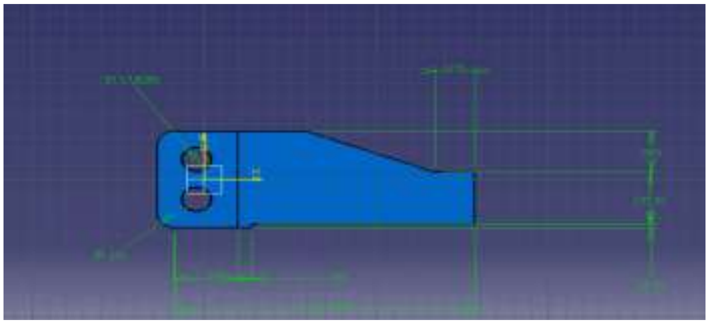

FIG.4. Figure showing the top view of the bracket

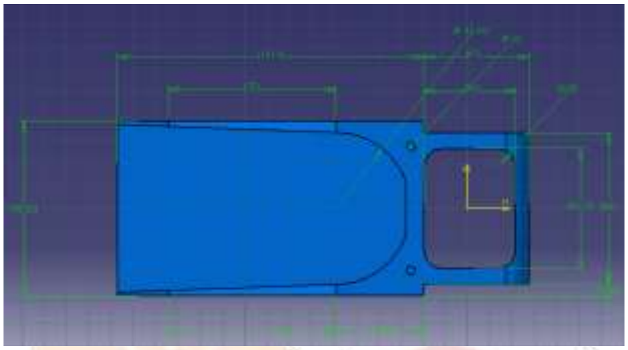

FIG.5. Figure showing constrained bracket

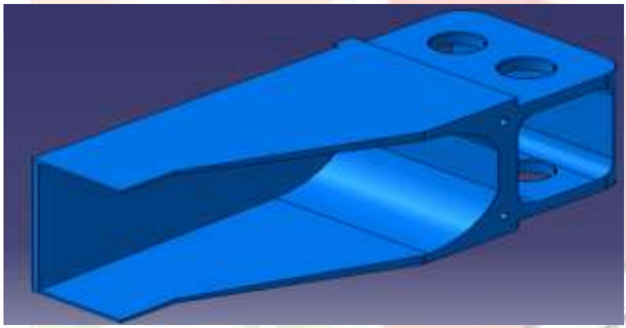

FIG.6. Figure showing the isometric view

5. STRUCTRUAL ANALYSIS OF THE WING BRACKET: In order to analyze the designed wing bracket geometry PATRAN software is used. PATRAN is a pre and post processing package for the finite element program. The designed geometry is imported into this software from the IGES file. The model is analyzed by the finite element method (FEM). The finite element mesh can be created immediately after the geometry has been created. The material properties are assigned to the geometry. Here we selected the aluminum as material which is suitable for the condition i.e., it is weightless and strong compared to the other materials. The aluminum wing-fuselage brackets have the capacity to withstand the air loads that can be transferred to the fuselage without any failure. The material's properties like Young's modulus, elasticity etc is assigned to the bracket geometry. After adding the material the bracket is then constrained.

There are two types of constraints: Single point constraint (SPC) and multi point constraint (MPC).The bracket is constraint with MPC for load application. The loadings are specified in the geometry and applied.

A text file is created according to the geometry and its specifications assigned to it. The tools in the PATRAN allow the user to submit an analysis to NASTRAN. All input and output to the program is in the form of text files and import the results and show them graphically in the PATRAN.

The structure is analyzed for shear load and bending load acting on it and it is shown graphically.

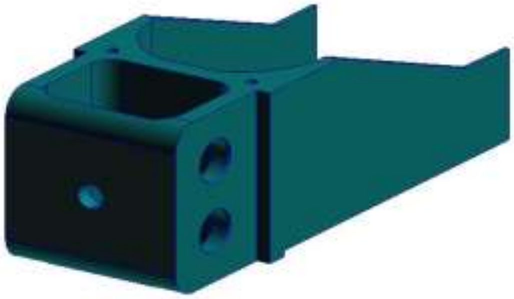

FIG.7. Bracket geometry imported into the patran window

The solid structure is imported into the Patran window for further analysis of the wing bracket.

5.1 Meshing

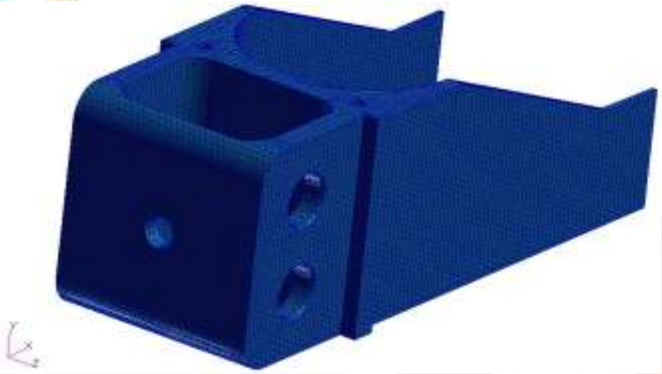

FIG.8. Meshed bracket

The bracket is meshed with tetra mesh. This is done for the finite element analysis of the solid.

5.2 Wireframe

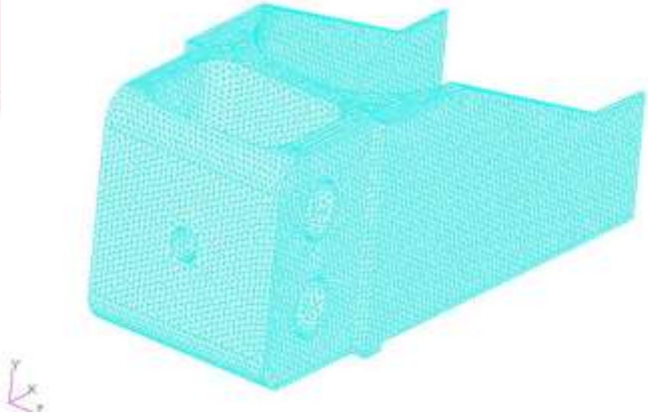

Fig.9. Wireframe image of bracket

5.3. Multi Point Constraining

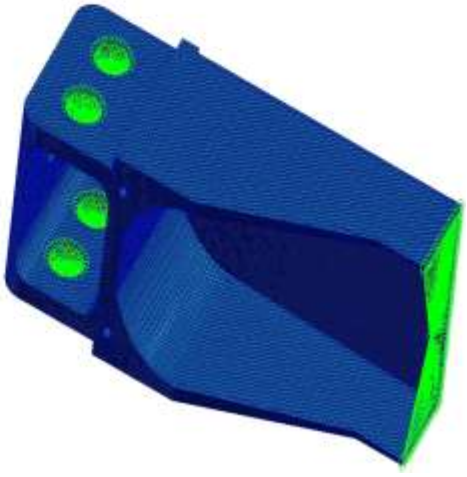

FIG.10. Load acting centre

5.4 Load Estimation of the Wing Bracket

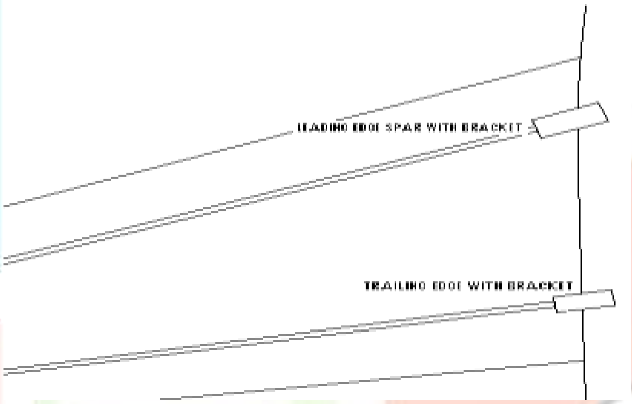

Fig.11. Position of the bracket in an aircraft

5.5. Load Calculation

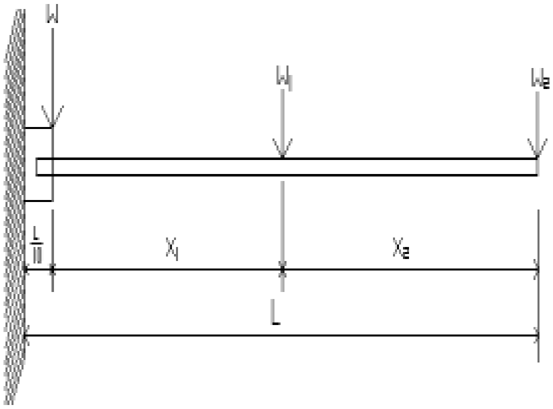

Fig.12. figure showing the cantilever beam

L = Total length, W = Total load, W_1 & W_2 = Forces acting on the wing , X_1 & X_2 = distance

Here the wing bracket is designed in such a way that it will allocate 10% of the total length (i.e. L/10). In a wing there are normally two wing brackets, one at leading edge and another at the trailing edge. In that, leading edge has to take 75% of the total load acting on the wing and remaining will be taken by the trailing edge. It has been found that maximum load acting on this UAV's wing is almost 12017 N and thus 75% of that load is 9012.94 N acting on the leading edge and remaining 3004.313N acting on the trailing edge.

5.6. Deflection Of The Bracket

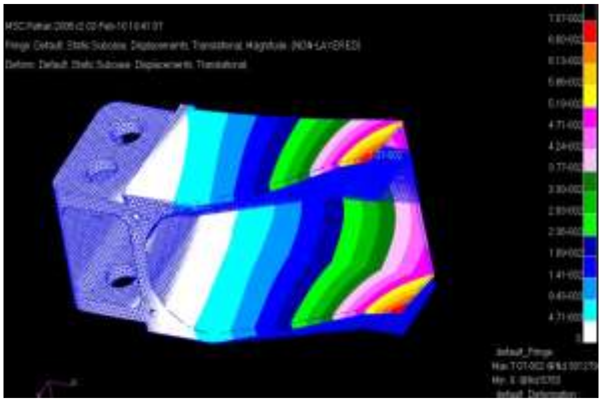

Fig.13 showing deflection of the bracket.

6. RESULT OF DEFLECTION ANALYSIS

Maximum deflection is 7.07mm in the bracket which is considered to be negligible and thus the designed bracket is successful.

6.1 STRESS ANALYSIS

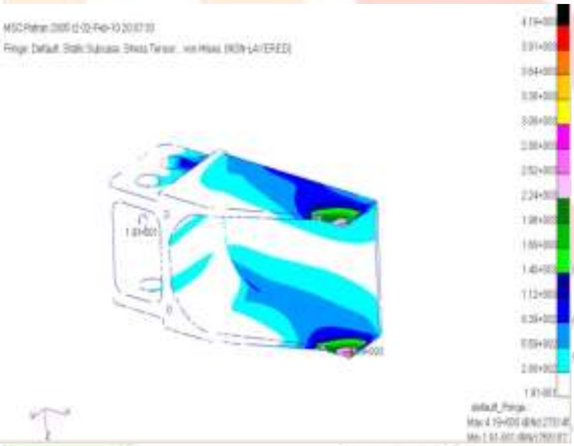

Fig.14 showing stress on the bracket

Maximum stress and Minimum stress in the bracket were found out which were in structural limit which is tabulated.

6.2 Analysis of Result

Deformation	Acceptable Limit	Obtained Value
Deflection	10 mm	7.07mm
Load Factor	3.5	3
Stress	555+003N/mm	419+003N/mm

7. CONCLUSION

The analysis work can be extended for all other node deflection cases. The study can be extended and signified by reducing weight of an aircraft wings, fuel economy and more cruising speeds by using the composite materials it can attain all these factors. Nastran/Patran has the capability of analyzing the load factors, fuel mass ratio, deformation status deflection criteria with two or more materials imported on it.

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