ANALYSIS OF NATURAL FREQUENCY FOR AN AIRCRAFT WING STRUCTURE UNDER PRE-STRESS CONDITION

V. Saran*, V. Jayakumar, G. Bharathiraja
Department of Mechanical Engineering, Saveetha School of Engineering, Saveetha University, Chennai, Tamilnadu, India

K. S. Jaseem
Technical Support Engineer, CAD Solutions, Coimbatore, Tamil Nadu, India

G. Ragul
Department of Mechanical Engineering, Budge Budge Institute of Technology, Kolkata, India

ABSTRACT

The content of this paper is all about the analysis of natural frequency for avoiding resonance on the material to prevent failure and to simulate according to the boundary conditions. The Vibrations of an aircraft wing structure is analyzed using CATIA and ANSYS software. The natural frequency of the component is analyzed by the frequency at which a system vibrates about an altitude and a time period, when not subjected to a continuous or repeated external force. A wing structure is the main machine component of the aircraft which is connected to the fuselage and it is acts like a cantilever beam in which the one end of the wing is fixed and other end remains free at the end. The wing structure consists of spars, stingers, rear ribs, mid ribs and skin. In pre-stress condition, the pressure force is acting on the wing structure while flying in the sky, the overall deformation of the wing structure is calculated using a ANSYS workbench. By analyzing the frequency of the wing structure its helps to calculate resonance that should not be equal to or more than the natural frequency. The material used for aircraft wing is aluminum alloy which is less in weight and having density, one third of the steel that does not affects its strength.

Keywords: Wing structure, Natural frequency, Resonance, Failure, Ansys Workbench, Deformation.


http://www.iaeme.com/IJMET/issues.asp?JType=IJMET&VType=8&IType=8
1. INTRODUCTION

1.1 Wing Structure
A wing structure of an aircraft which is capable to fly with help of airfoil profile that generates lift by the vehicle's forward airspeed and the shape of the wings as shown in Figure 1. Fixed-wing aircraft follows the cantilever beam structure in which the one end is fixed to the fuselage and another is set to be the free end. The aircraft wing model is created according to the data available and value found from the geometry and trigonometric relation.

![Figure 1 Aero foil diagram of an aircraft wing structure](image)

1.1.1 Components of Wing Structure
Rib is one of the elements in the wing structure, especially in conventional construction [1]. Ribs are made out of wood, metal, plastic, composites, foam. Ribs are classified into three main parts. They are front-rib, middle-rib and rear-rib. The rib construction of an aircraft wing is shown in Figure 2.

![Figure 2 Wing Structure](image)
Spar is the main structural member of the wing structure, constructed at span-wise at right angle to the fuselage as shown in Figure 2. The spar carries the whole weight of the wings while on the ground. Apart from that other structural and forming members such as ribs may be attached to the spar. Skin is as of the minimum thickness for resisting the pressure applied on it while flying on the sky from 0.015 to 0.025 inches \[2\]. The strength requirements are should be relatively low; the skin needs moderately high yield strength and hardness to minimize ground damage from stones, debris, mechanic’s tools, and general handling.

The objective of this work is to calculate the resonance of the machine component (aircraft wing) to prevent the critical vibrations which causes deformation. Resonance is a phenomenon that occurs when a vibrating system or external force drives another system to oscillate with greater amplitude at a specific preferential frequency \[4\]. Natural frequency is the frequency at which a system tends to oscillate in the absence of any driving or damping force.

2. MODAL ANALYSIS
The purpose of modal analysis in design mechanics is to determine the natural mode shapes and frequencies of an object or structure during free vibration. It is generally to use the finite element analysis (FEA) to perform this analysis. Modal analysis of the wing structure is analyzed with and without pre-stress conditions. Pre-stress means of permanent stresses in a structure for the purpose of improving its performance under various service conditions. In pre-stress condition, the wing is subjected to pre-stress modal to static structural and modal analysis to analyze the natural frequency in all nodal displacements using Ansys software \[5-9\].

3. TOTAL DEFORMATION

3.1. Deformation 1
Figure 3 represents the total deformation of the wing structure at the first nodal displacement, in which at one end the deformation is maximum highlighted in red color and the blue color denotes the minimum deformation occurs due to frequency of the aircraft wing while flying in sky.

![Figure 3 Deformation 1](image)

3.2. Deformation 2
Figure 4 represents the total deformation of the wing structure at the second nodal displacement, in which at one end the deformation is maximum highlighted in red color and the blue color denotes the minimum deformation occurs due to frequency of the aircraft wing while flying in sky.
3.3. Deformation 3
Figure 5 represents the total deformation of the wing structure at the third nodal displacement, in which at one end the deformation is maximum highlighted in red color and the blue color denotes the minimum deformation occurs due to frequency of the aircraft wing while flying in sky.

3.4. Deformation 4
Figure 6 represents the total deformation of the wing structure at the fourth nodal displacement, in which at one end the deformation is maximum highlighted in red color and the blue color denotes the minimum deformation occurs due to frequency of the aircraft wing while flying in sky.

3.5. Deformation 5
Figure 7 represents the total deformation of the wing structure at the fifth nodal displacement, in which at one end the deformation is maximum highlighted in red color and the blue color denotes the minimum deformation occurs due to frequency of the aircraft wing while flying in sky.
3.6. Deformation 6

Figure 8 represents the total deformation of the wing structure at the sixth nodal displacement, in which at one end the deformation is maximum highlighted in red color and the blue color denotes the minimum deformation occurs due to frequency of the aircraft wing while flying in sky.

Total deformation of the wing structure according to its nodal displacement as shown in the Table 1

<table>
<thead>
<tr>
<th>Total Deformation</th>
<th>Max. Deformation, m</th>
<th>Min. Deformation, m</th>
<th>Frequency, Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.12</td>
<td>0.0</td>
<td>73.93</td>
</tr>
<tr>
<td>2</td>
<td>0.14</td>
<td>0.0</td>
<td>412.05</td>
</tr>
<tr>
<td>3</td>
<td>0.122</td>
<td>0.0</td>
<td>439.37</td>
</tr>
<tr>
<td>4</td>
<td>0.187</td>
<td>0.0</td>
<td>518.1</td>
</tr>
<tr>
<td>5</td>
<td>0.14</td>
<td>0.0</td>
<td>1003.1</td>
</tr>
<tr>
<td>6</td>
<td>0.174</td>
<td>0.0</td>
<td>1359.8</td>
</tr>
</tbody>
</table>

Table 1 Modal analysis of wing structure with pre-stress

4. CONCLUSIONS

The Natural frequency of the wing structure is analyzed within the pre-stress with the help of Ansys Workbench 16.2 software. According to the resonance factor it tends to failure of the wing. The overall deformation of the wing structure is determined under pre-stress while flying using the modal analysis in the Ansys. By knowing the natural frequency of the aircraft wing, it helps to calculate the resonance of the wing structure. The resonance of the wing structure is determined to prevent the failure of the component in the aircraft.
REFERENCES


