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VIBRATIONAL ANALYSIS OVER AN AIRCRAFT WING DURING CRUISE SPEED

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Abstract: In our project we are going to analyze the stress distribution over a modern passenger aircraft due to vibration that had been induced during cruise flight. We had taken a subsonic passenger aircraft as a reference flight and analyzed using FEA optimization tool. By this analysis we can able to find the natural frequency of an aircraft wing design and from this result we can able to optimize the wing support structures of an aircraft. The main advantages of this project are we can increase the aircraft stability during cruise and also we can increase the life of an aircraft wing and its support structures.

Keywords: Kinetic Energy, Flywheel, Efficiency

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INTRODUCTION

Wing is the main lifting device in the aircraft so that it should have the structural integrity for various bending and twisting. Due to these bending at some case stresses will be maximum at critical location. To find such locations we are using the analyzing software as a tool.

Due to high speed the maximum lift force will be produced over the wing surface. Hence due to this lift force and G-Forces the aircraft wing will starts to vibrate this will reduce the stability of an aircraft. The boundary conditions are taken from the passenger aircraft survey reports including maximum lift force distribution over the wing and the G-Forces is calculated.

Normally in analysis we used to choose the ultimate condition so in order to check the reliability of an aircraft wing. We had designed our own wing with the reference of subsonic passenger aircraft.

PROBLEM SPECIFICATIONS

From the literature survey we came to know that aircraft life has been depending on structural behavior of wing. But nowadays while optimizing the aircrafts such dynamic behavior for the aircraft wing also considered.

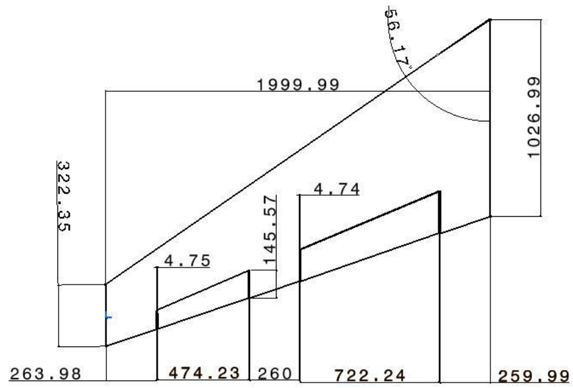
The aircraft structures life had been reduced due to unwanted vibrations that take place due to air flow distributions over it. The life of the supporting structures had been reduced due to different mode shapes of the aircraft wings which occur at various frequencies.

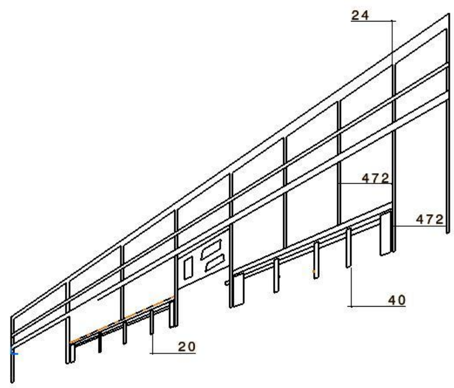
Due to this different mode shapes the coupling structures near the wing root and fuselage will undergo high stress.

There will be difference if we used to analysis the wing structure statically in FEA. The load is tribution will not be same over the wing structures.

Stresses are the main criteria where it will reduce the fatigue life of the aircraft wing; these will decrease the servicing life of wing and increase the overhauling or replacement maintenance. In the aircraft, engines are placed in wing so that if wing is not having the concern structural integrity then it will affect the engine life also. These are main problems occur while designing the aircraft.

GEOMETRY DETAILS





Boundary Condition

For load case-1:

Acceleration is taken as 10g (Gravity load)

For load case-2:

Max Lift coefficient, $\mathbf{C_L=0.795}$

Velocity, **v=300m/s**

Wing span, **s=2000mm**

Average chord, **C=674mm**

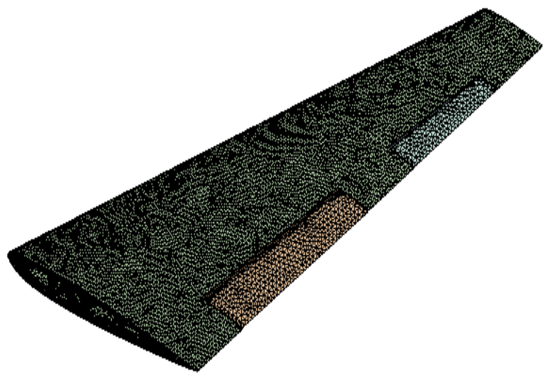
AR=2.96

Planform area, **A= 1351351.35 mm^2**

L=Lift force

L=59285N.

FEA Model:



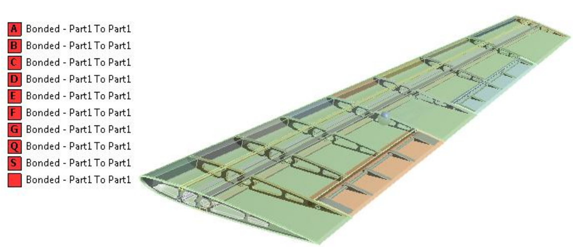
The above shown is the meshed model of the wing.

Element count: 462913

Node count: 126712

Element type: 4-noded Tetrahedral structural solid, 3 Degree of freedom (ux, uy,uz).

Contact Details:



As per the analysis software it will calculate the result at each node, so that after meshing sub assembly should have the connectivity between each assembly.

For creating the connectivity between the assembly for load transfer there is one option is there in ANSYS workbench i.e., Connections.

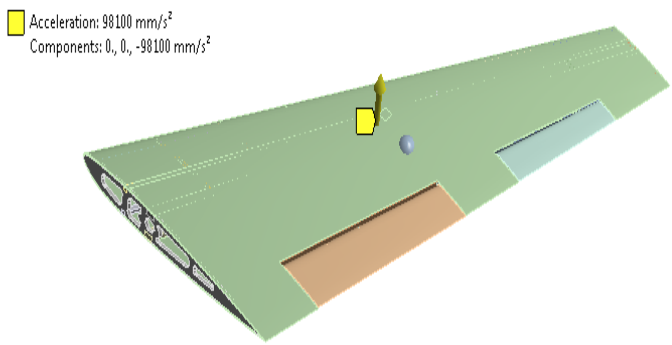
Contact is nothing but it will resemble the practical case as per our analysis approach. It will maintain the connectivity between the assemblies for load transfer between the nodes.

There are different types of contacts are there that also depends on analysis. For our approach we creating bonded contact between sub-assemblies.

In above shown figure between ribs and spar, ribs and outer sheet are having bonded contacts.

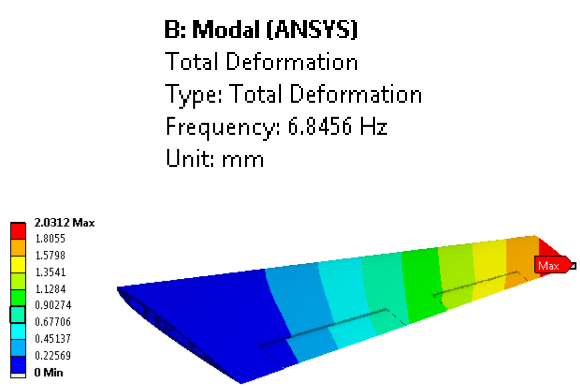
Boundary conditions:

Load case: 1

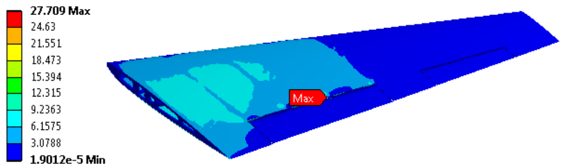


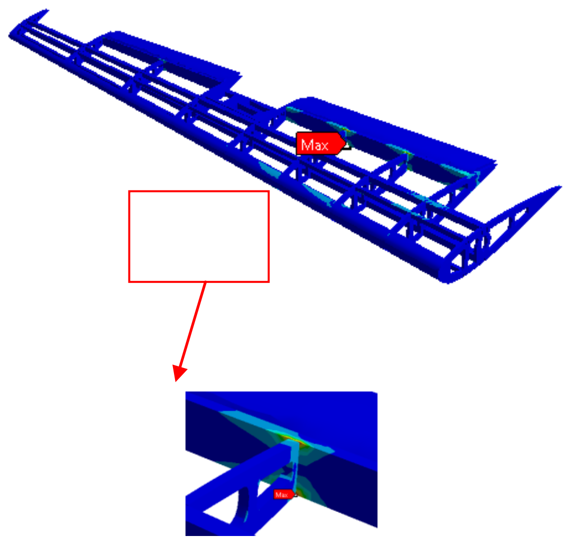
For Load Case 1:10gAcceleration

Deformation Plots:



B: Modal (ANSYS)
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Frequency: 6.8456 Hz
Unit: MPa





Maximum stress is at the rib and spar contact region for this mode.

Comparative study

For load case-1:10g Acceleration

Step	Modes	Description	Total Deformation	Von-mises Stress
1	6.8546	Vertical bending	2.03	27.709
2	19.961	Lateral bending	3.50	126.67
3	36.035	Second vertical bending	1.99	177.64
4	43.22	Local outboard aileron	5.33	1110
5	50.975	Second Local outboard aileron	6.88	1806.3
6	60.10	Third Local outboard aileron	6.77	2130.4

For load case-2: Lift force

Step	Modes	Description	Total Deformation	Von-mises Stress
1	6.8499	Vertical bending	2.03	27.87
2	19.971	Lateral bending	3.5061	126.3
3	36.037	Second vertical bending	1.9919	177.49
4	43.23	Flap vertical bending	5.37	1116.3
5	50.99	Local outboard aileron	6.89	1812.7
6	60.133	Second Local outboard aileron	6.25	2136.9

The above results are shown for two approaches of different load cases results. One is with maximum 10g acceleration load application and another is lift force load application as shown above.

CONCLUSION:

The paper gives the deformation details of the aircraft wing at no load and maximum load conditions. The deformation results can be used to strengthen the sections of the wing components to avoid the structural damage. The exact area of the maximum stress is pointed out to rectification. Further scope of the paper lies in the elaborate design rectification with the result stated.

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