Life Span Improvement of Aircraft's Wing Box through Displacement, Stress and Vibration Analysis

DeepRani.K[1], Dr.S.SambuPrasad[2], D.J.Johnson[3]

[1]*Student, Department of Mechanical Engineering, PRAGATI Engineering College, Surampalem, A.P, INDIA*

[1]deepranirao@gmail.com

[2]*Professor, Department of Mechanical Engineering, PRAGATI Engineering College, Surampalem, A.P, INDIA*

[2]*ssambhuprasad@yahoo.co.in*

[3] *Assistant professor, Department of Mechanical Engineering, PRAGATI Engineering College, Surampalem, A.P, INDIA*

[3]d.jasperjohnson@gmail.com

***Abstract*— This project deals with the displacement and vibration analysis of aircraft wing box. The aim of the project is to find the suitable material to improve the strength of aircraft wing box. By using Pro-E crio 1.0 2Ddrawings are drafted and further analysis is carried out by using ANSYS 11.0. During the flight aircraft wings experience so many forces due to drag, gravitation, and some disturbances like vibrations and fuel load. The strength and life span of the air wing depends on these forces. So to increase the life span and strength of the wing box, we replace the existing materials with high strength materials. Displacement and vibration analysis is done on the aircraft wing box both in static and dynamic conditions. Analysis is conducted when the fuel tank is completely filled with fuel and using five materials i.e., Wrought aluminium alloy 2014, Wrought aluminium alloy 2124, Wrought aluminium-magnesium alloy 5052, Wrought aluminium-magnesium-silicon alloy 6061, Wrought aluminium-zinc-magnesium alloy 7075.**

***Keywords*— aircraft wing internal structure, wing box, static and dynamic analysis, Pro-E crio 1.0, Ansys 11.0.**

I. INTRODUCTION

The wings of an aircraft are designed to lift it into the air. Their particular design for any given aircraft depends on a number of factors, such as size, weight, use of the aircraft, desired speed in flight and at landing, and desired rate of climb. The wings of aircraft are designated left and right, corresponding to the left and right sides of the operator when seated in the cockpit.

Wing structure is a replica of a cantilever design which is supported internally by structural members assisted by the skin of the aircraft. The loads applied on the wing are engine load, fuel load and opposing force on the wing structure when the air craft is moving. The selection of the material is very important for the construction of wing and must have high strength, high resistant to vibration as well as displacement which helps in increasing the life span of the wing structure.

II. MATERIAL STUDY

Selecting the best material to use for a particular application is not straightforward. It will depend on many factors including customer requirements (e.g. performance, cost, and safety), design requirements (e.g. strength, temperature capability, density) and material technology prospects (e.g. materials/processes currently and potentially available). For aerospace applications, the large number of safety requirements such as the protection against bird, ballistic and lightning strike and events like fire and fan blade off, makes finding an appropriate material particularly challenging.

The key factor in choosing the material for the construction of air wing box should possess high specific strength and less weight, thereby reducing fuel burn and operating cost. The main objective in choosing the material with the properties mentioned is to increase the life span of the construction. Wrought Aluminium alloy 2014 is the most common material used for constructing wings; now a days, the modern aircrafts design is mainly concentrating towards lighter and stronger materials throughout the airframe and in wing construction.

Materials selected for the analysis consist of wrought aluminium alloy 2124, wrought aluminium-magnesium alloy 5052, wrought aluminium-magnesium-silicon alloy 6061, and wrought aluminium-zinc-magnesium alloy 7075 and the analysis of these materials is compared with wrought aluminium alloy 2014.

III. WING DESIGN

3.1 Modelling of aircraft wing box by pro-e software:

Pro-e crio 1.0 is one of the best modelling software which gives the real feel for visualisation of the design. The dimensions of air wing are taken from standard designs which are shown in the fig.3.1. 1. The main focus of this project is to find alternative better materials to increase the strength of the wing box. In this modelling the basic design of the air wing is further simplified to avoid complexity for the analysis. So a simplified model is done by using Pro-e modelling software.

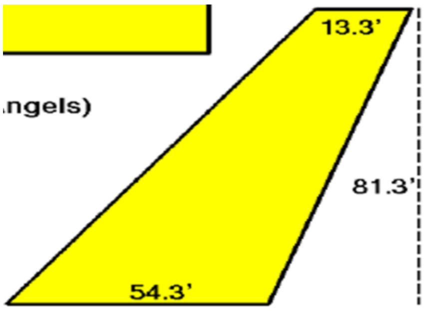

Fig.3.1.1 Standard Design of Air Wing Box

3.2 Pro-E Model:

The design model of wing box is shown in figure 3.2.1 below.

Fig.3.2.1 Design Model Of Wing Box

The details of the loads applied at various nodes of the wing boxare as follows.

At node1=3.75E+05

At node 2=3.00E+05

At node 3=1.15E+05

IV. FINITE ELEMENT ANALYSIS ON AIRCRAFT WING BOX USING ANSYS 11.0 WITH DIFFERENT MATERIALS

The Finite Element method is a mathematical tool for solving ordinary and partial differential equation. It has the ability to solve the complex problem that can be represented in differential equation form. The application of FEM is limitless as regards the solution of practical design problems. The analysis part is done by importing the model from Pro-E to ANSYS 11.0.

4.1 Static analysis report:

The static analysis indicating displacement (fig 4.1.1) and stress (fig 4.1.2) values for the five materials is tabulated in table 4.1.1.

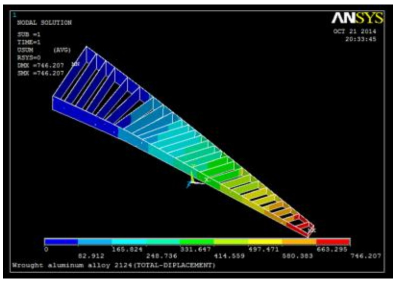

Fig.4.1.1 Deformation Report

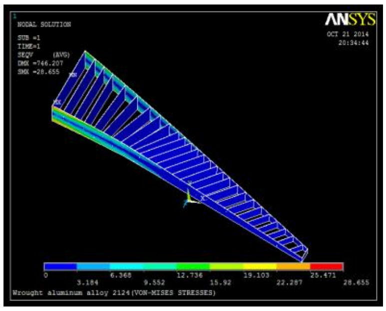

FIG.4.1.2 STRESS ANALYSIS REPORT

Type Of Wrought Aluminium Alloy	Von-Mises Stress (MPa)		Displacement (m)
	Max	min	
Al 2014	180.346	0	4636
Al 2124	28.655	0	746.207
Al-Mg 5052	139.431	0	4560
Al-Mg-Si 6061	161.704	0	4670
Al-Zn-Mg 7075	168.012	0	4627

Table 4.1.1 summary of displacement and stress values of all the material

From the table 4.1.1 it is observed that wrought aluminium 2124 has less stress and displacement compared to all other materials considered for analysis.

4.2 Dynamic analysis report:

The dynamic analysis indicating vibration (from fig.4.2.1 to fig.4.2.5) values for the five materials is tabulated in table 4.2.1

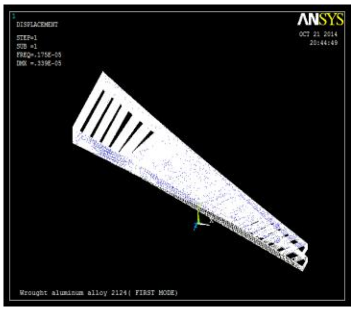

Fig.4.2.1 Mode1

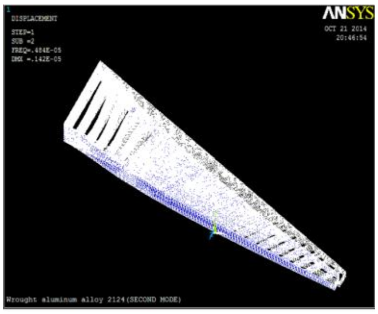

Fig.4.2.2 Mode 2

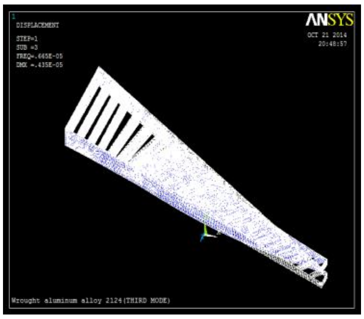

Fig.4.2.3 Mode3

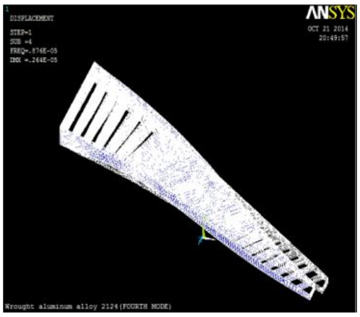

Fig.4.2.4 Mode 4

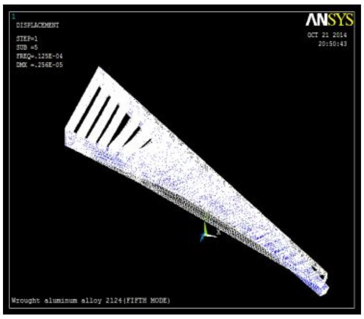

Fig.4.2.5 Mode 5

Type Of Wrought Aluminium Alloy	Frequency				
	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
Al 2014	7.23E-05	2.13E-04	2.73E-04	3.74E-04	5.24E-04
Al 2124	1.75E-06	4.84E-06	6.65E-06	8.76E-06	1.25E-05
Al-Mg 5052	1.75E-06	4.84E-06	6.66E-06	8.78E-06	1.25E-05
Al-Mg-Si 6061	1.72E-06	4.77E-06	6.56E-06	8.64E-06	1.23E-05
Al-Zn-Mg 7075	1.73E-06	4.78E-06	6.57E-06	8.66E-06	1.23E-05

Table 4.2.1 summary of vibration analysis of all the materials

From table 4.2.1, we can observe that wrought aluminium-magnesium-silicon alloy 6061 has high vibration resistance among all other materials of wing box.

V. CONCLUSION

By observing the static analysis report of the existing material and other selected materials, it is found that the stress and displacement in wrought aluminium alloy 2124 is less compared to all other materials. Through dynamic analysis, it is observed that the wrought aluminium-magnesium-silicon alloy 6061 has high resistance for vibrations when compared with other materials. But by considering both the static and dynamic reports, wrought aluminium alloy 2124 depicted better results compared to the other materials considered for study. Hence it is concluded that the wrought aluminium alloy 2124 is preferable among all other materials which has the ability to increase the strength and life span of aircraft wing box.

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