DESIGN AND STATISTICAL ANALYSIS OF THE WING STRUCTURE OF A TRAINER AIRCRAFT IN ORDER TO PREDICT ITS FATIGUE LIFE

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Abstract

Within the scope of this study, a CATIA project was used to create a thorough design of a trainer aircraft wing structure. After that, a stress analysis of the wing structure is carried out in order to calculate the stresses that are being placed on the wing structure. In order to calculate the structure's safety factor, the finite element method along with ANSYS's assistance is used to make an estimate of the stresses. In a structure such as an aircraft, a fatigue fracture could develop at the spot where the tensile stress is the highest. Life prediction necessitates the use of a model for the accumulation of fatigue damage, constant amplitude S-N (stress life) data for a variety of stress ratios, and local stress history at the stress concentration. It is planned to analyse the reaction of the structure of the wing. The complete investigation of the trainer aircraft wing structure, including the skin, spars, and ribs, is the focus of this particular piece of research. The structure of the wing is made up of 15 ribs and two spars that are covered with skin. A "I" segment is located on the front spar, while a "C" section is located on the rear spar. In order to calculate the stresses that will be placed on the spars and ribs as a result of the imposed pressure load, a stress and fatigue study of the whole wing section must first be performed.

Keywords*: Aircraft wing, CATIA, Ansys, static analysis, and fatigue life prediction.*

1. INTRODUCTION

A wing is a type of fin that produces lift, while moving through air or some other fluid. As such, wings have streamlined cross-sections that are subject to aerodynamic forces and act as airfoils. A wing's aerodynamic efficiency is expressed as its lo-drag ratio. The lift a wing generates at a given speed and angle of attack can be one to two orders of magnitude greater than the total drag on the wing. A high lift-to-drag ratio requires a significantly smaller thrust to propel the wings through the air at sufficient lift. Lifting structures used in water, include various foils, including hydrofoils. Hydrodynamics is the governing science, rather than aerodynamics. Applications of underwater foils occur in hydroplanes, sailboats and submarines.

1.1 Aircraft wing

The wing might be considered as the most significant part of a flying machine, since a fixed-wing flying machine can't fly without it. Since the wing geometry and its highlights are affecting all other air ship parts, we start the detail configuration process by wing structure. The essential capacity of the wing is to produce adequate lift power or just lift (L). Be that as it may, the wing has two different preparations, specifically drag power or drag (D) and nose-down pitching minute (M). While a wing architect is hoping to amplify the lift, the other two (drag and pitching minute) must be limited. Actually, wing is expected promotion a lifting surface that lift is created because of the weight distinction among lower and upper surfaces. Streamlined features course readings might be concentrated to revive your memory about numerical systems to figure the weight conveyance over the wing and how to decide the stream factors.

2. MODELING AND ANALYSIS

Computer-aided design (CAD) is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term CADD (for Computer Aided Design and Drafting) is also used. Its use in designing electronic systems is known as electronic design automation, or EDA. In mechanical design it is known as mechanical design automation (MDA) or computer-aided drafting (CAD), which includes the process of creating a technical drawing with the use of computer software.

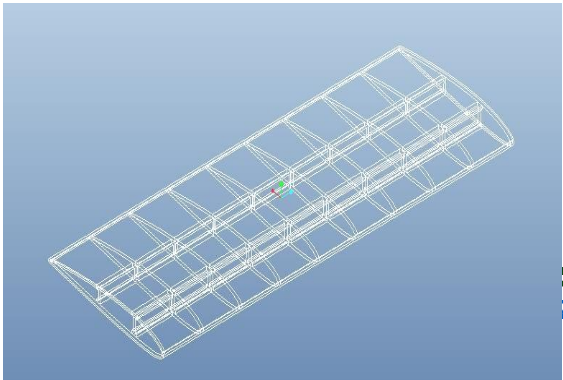


Fig. 1: 3D model of ribs and spars

CATIA is an acronym for Computer **A**ided **T**hree-dimensional **I**nteractive **A**pplication. It is one of the leading 3D software used by organizations in multiple industries ranging from aerospace, automobile to consumer products. CATIA provides the capability to visualize designs in 3D. When it was introduced, this concept was innovative. Since Dassault Systems did not have an expertise in marketing, they had revenue sharing tie-up with IBM which proved extremely fruitful to both the companies to market CATIA. In the early stages, CATIA was extensively used in the design of the Mirage aircrafts; however the potential of the software soon made it a popular choice in the automotive sector as well. As CATIA was accepted by more and more manufacturing companies, Dassault changed the product classification from CAD / CAM software to Project Lifecycle Management. The company also expanded the scope of the software. Structural analysis consists of linear and non-linear models. Linear models use simple parameters and assume that the material is not plastically deformed. Non-linear models consist of stressing the material past its elastic capabilities. The stresses in the material then vary with the amount of deformation as in. Vibrational analysis is used to test a material against random vibrations, shock, and impact. Each of these incidences may act on the natural vibrational frequency of the material which, in turn, may cause resonance and subsequent failure. Fatigue analysis helps designers to predict the life of a material or structure by showing the effects of cyclic loading on the specimen. Such analysis can show the areas where crack propagation is most likely to occur. Failure due to fatigue may also show the damage tolerance of the material.

Material properties ALUMINUM 6061-T8

Density = 2.7g/cc

Young's modulus = 69.0GPaPoisson's ratio = 0.33

S2 GLASS

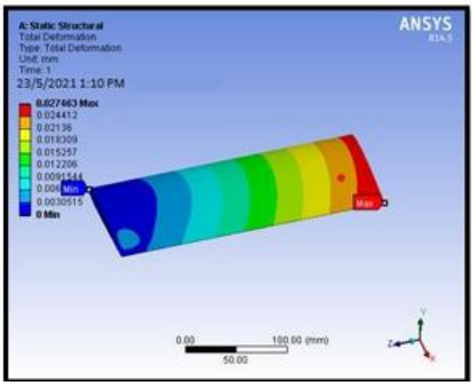
Density = 2.46g/cc

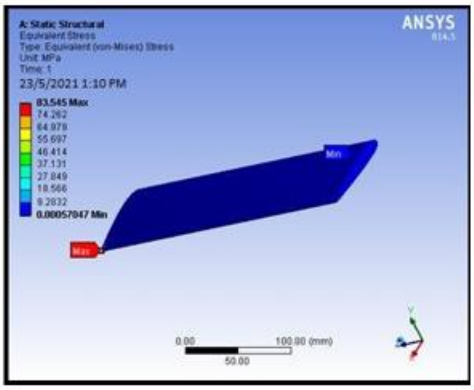
Young's modulus = 86.9GPaPoisson's ratio = 0.28

CARBON EPOXY

Density = 1.60g/cc

Young's modulus = 70.0GPaPoisson's ratio = 0.3





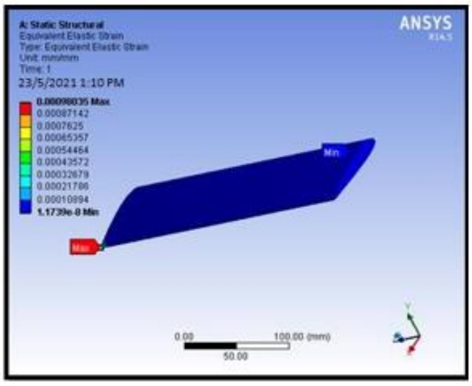
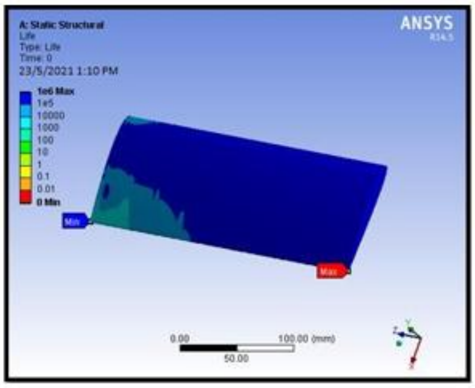


Fig. 2: Deformation (top left). Stress (top right). Strain (bottom).

3. FATIGUE ANALYSIS OF AIRCRAFT WING



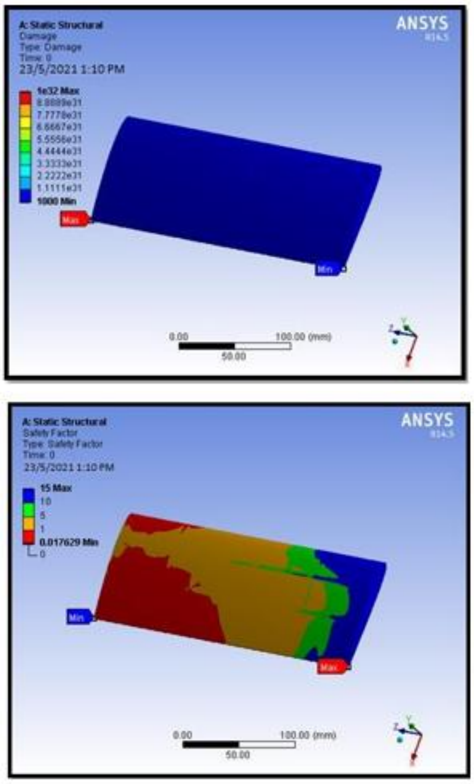


Fig. 3: Life (top left). Damage (top right). Safety factor (bottom).

4. RESULTS STATIC ANALYSIS

Material	Deformation(mm)	Stress (MPa)	strain
aluminum 6061-T8	0.034562	83.399	0.0012383
s2 glass	0.027463	83.545	0.00098035
carbon fiber	1.9943e-5	48.896	0.00071355

FATIGUE ANALYSIS

Material	life	damage	Safety factor
aluminum 6061-T8	1×e6	1×e32	0.010336
s2 glass	1×e6	1×e32	0.010318
carbon fiber	1×e6	1×e32	0.017629

5. CONCLUSION

In this article, the trainer aircraft wing structure with skin, spars and ribs is considered for the detailed analysis. The wing structure consists of 15 ribs and two spars with skin. Front spar having "I" section and rear spar having "C" section. Stress and fatigue analysis of the whole wing section is carried out to compute the stresses and life at spars and ribs due to the applied pressure load.

- By observing the static analysis of aircraft wing, the stress values are increases by increasing the speed of the aircraft wing, the less stress value for carbon epoxy than s2-glass and aluminum alloy 6061-T8. Carbon epoxy material has more strength because it is a composite material.
- By observing the modal analysis of aircraft wing, the deformation and frequency values are more for carbon epoxy material. By observing the fatigue analysis of aircraft wing, the safety factor value is more for carbon epoxy material.
- So, it can be concluded, the carbon epoxy material is better material for aircraft wing.

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