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DESIGN OPTIMIZATION AND STATISTICAL ANALYSIS OF TRAINER AIRCRAFT WING STRUCTURE TO PREDICT FATIGUE LIFE

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ABSTRACT

As part of this inquiry, the wing structure of a training aircraft was thoroughly designed using a CATIA project. After that, a stress study of the wing structure is performed to ascertain the stresses being applied to it. The finite element method is utilized to forecast the stresses in order to calculate the safety factor of the structure with the help of ANSYS. In a construction such as an airplane, a fatigue fracture can happen where the most tensile stress is applied. For life prediction, three things are needed: a model for the accumulation of fatigue damage; constant amplitude S-N (stress life) data throughout a range of stress ratios; and local stress history at the stress concentration. A structural response analysis of the wing is planned. This particular study looks at the trainer aircraft's wing structure, specifically the skin, spars, and ribs. The wing is made up of fifteen ribs and two spars covered in skin. The front spar has a "I" section and the back spar a "C" shape. To find the strains that the imposed pressure load will cause on the spars and ribs, a stress and fatigue assessment of the entire wing section must be finished.

The following are potential search terms: fatigue life prediction, static analysis, CATIA, Ansys, and aircraft wing.

INTRODUCTION

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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 l i f t -to-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.

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

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of creating a technical drawing with the use of computer software.

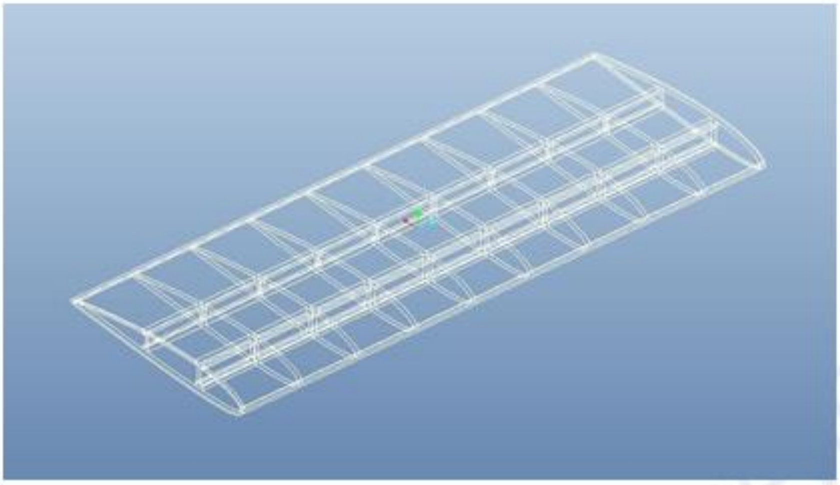

Fig. 1: 3D model of ribs and spars.

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 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 = 69.0GPa

Poisson's ratio = 0.33

S2 GLASS

Density = 2.46g/cc

Young's modulus = 86.9GPa

Poisson's ratio = 0.28

CARBON EPOXY

Density = 1.60g/cc

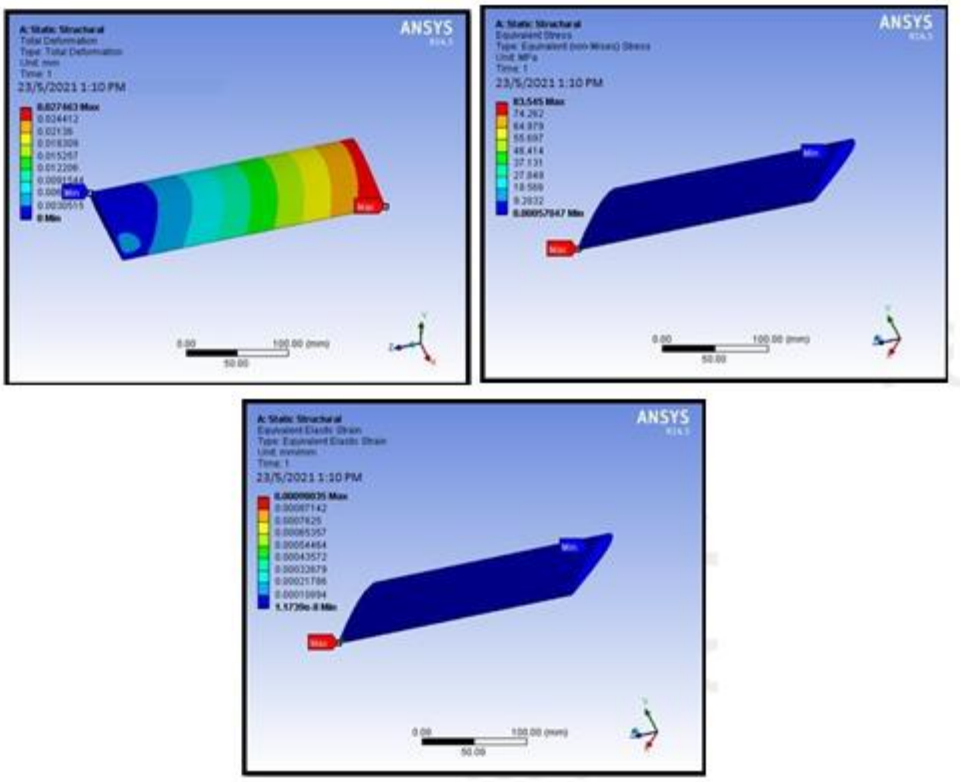

Fig. 2: Deformation (top left). Stress (top right). Strain (bottom).

2. FATIGUE ANALYSIS OF AIRCRAFT WING

Young's modulus = 70.0GPa

Poisson's ratio = 0.3

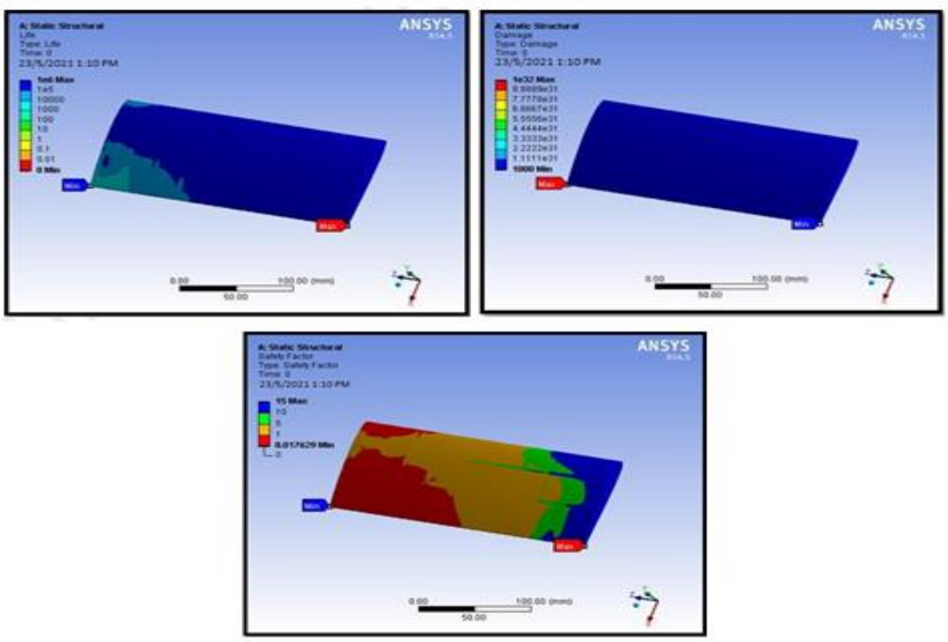

Fig. 3: Life (top left). Damage (top right). Safety factor (bottom).

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

CONCLUSION

The skin, spars, and ribs of the trainer aircraft wing construction are all described in detail on this page. The wing structure consists of fifteen ribs and thin skin. The Engineering Scientists' Journal. The front spar's "I" segment and the rear spar's "C" part. A stress and fatigue study of the entire wing section is carried out in order to determine the stresses and life at spars and ribs as a result of the applied pressure load.

- A static analysis of an airplane wing shows that when the wing's speed rises, the stress levels increase. The stress value of carbon epoxy is lower than that of s2-glass and aluminum alloy 6061-T8. Carbon epoxy is stronger since it is a composite material.

- An airplane wing's modal study reveals that the carbon epoxy material has higher deformation and frequency values. Carbon epoxy material has a higher safety factor value based on an analysis of aircraft wing fatigue.

- As a result, carbon epoxy is a better material to use for airplane wings.

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