DOI: 10.48047/intjecse/V10I2.31 ISSN: 1308-5581 Vol 10, Issue 02 2018

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.
Aircraft wing, CATIA, Ansys, static analysis, and fatigue life prediction are some of the keywords that may be found here.

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 -to-drag ratio. The lifta wing generates ata 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 foilsoccurin hydroplanes, sail boatsand submarines.

1.1 Aircraftwing

The wing might be considered as the most significant part of a flying machine, since a fixed-wingflying machine can't fly without it. Since the wing geometry and its highlights are affecting all otherair ship parts, we start the detail configuration process by wing structure. The essential capacity of thewing is to produce adequate lift power or just lift (L). Be that as it may, the wing has two differentpreparations, specifically drag power or drag (D) and nose-down pitching minute (M). While a wingarchitect 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 weightdistinctionamonglowerandupper surfaces.Streamlinedfeaturescoursereadingsmightbeconcentrate d to revive yourmemory about numerical systemsto figure the weightconveyance overthe wingand how todecidethe streamfactors.

2. MODELINGANDANALYSIS

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 productivityof the designer, improve the quality of design, improve communications through documentation, andto 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 andDrafting) 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

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automation (MDA)or computer-aided drafting (CAD), which includes the process of creating a technical drawing with theuseof computersoftware.

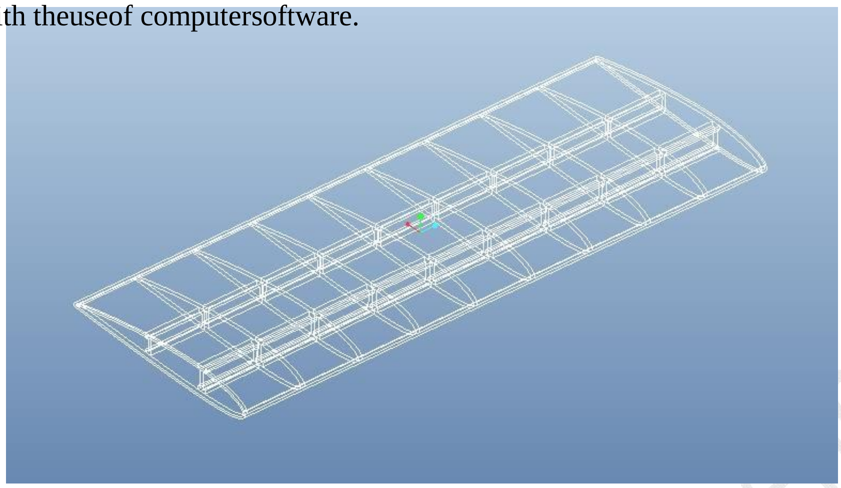

Fig.1:3Dmodelofribsand spars.

CATIA isan acronym for Computer **A**ided **T**hree-dimensional **I**nteractive **A**pplication.Itisone oftheleading3Dsoftwareusedbyorganizationsinmultipleindustriesrangingfromaerospace,automobile to consumer products. CATIA provides the capability to visualize designs in 3D. When itwas introduced, this concept was innovative. Since Dassault Systems did not have an expertise inmarketing, they had revenue sharing tie-up with IBM which proved extremely fruitful to both thecompanies to market CATIA. In the early stages, CATIA was extensively used in the design of the Mirage aircrafts; however the potential of the softwaresoon 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 fromCAD/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 andassumethatthematerial isnotplastically deformed.Non-linearmodelsconsistofstressing thematerialpastitselasticcapabilities.

Thestressesinthematerialthenvarywiththeamountofdeformationasin.Vibrationalanalysisisusedtotestama terialagainstrandomvibrations,shock,and impact. Each of these incidences may act on the natural vibrational frequency of the materialwhich, in turn, may cause resonance and subsequent failure.Fatigue analysis helps designers topredict 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 tofatiguemayalso showthedamage toleranceof the material.

Material propertiesALUMINU M6061-T8

Density=2.7g/cc

Young's modulus = 69.0GPaPoisson'sratio =0.33

S2GLASS

Density= 2.46g/cc

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

Density= 1.60g/cc

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Young’s modulus = 70.0GPaPoisson’sratio = 0.3

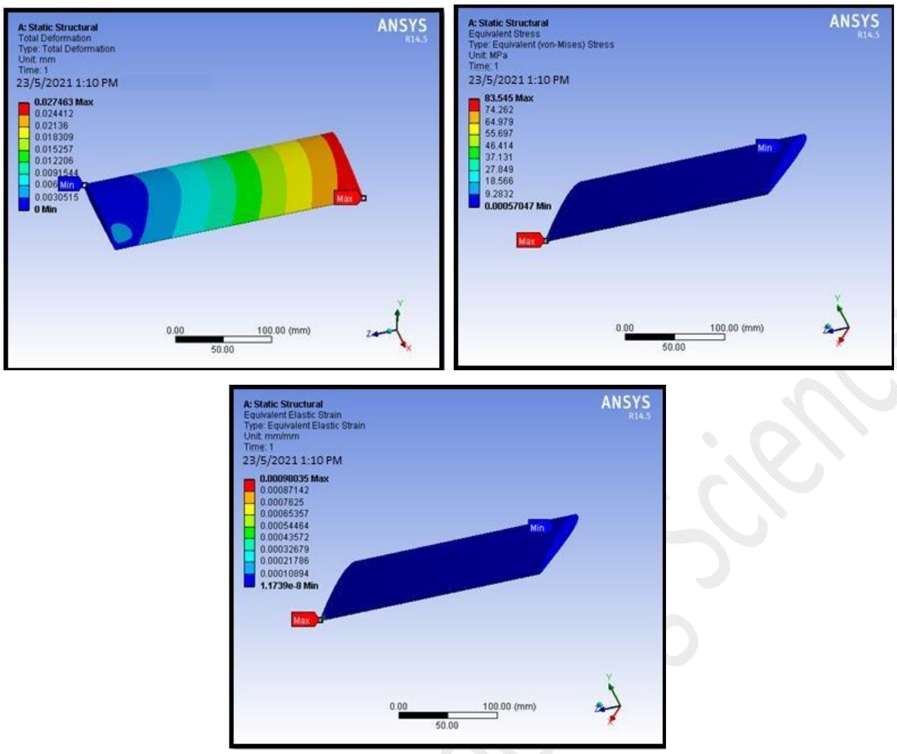

Fig.2:Deformation(topleft).Stress(topright).Strain(bottom).

3. FATIGUEANALYSISOF AIRCRAFTWING

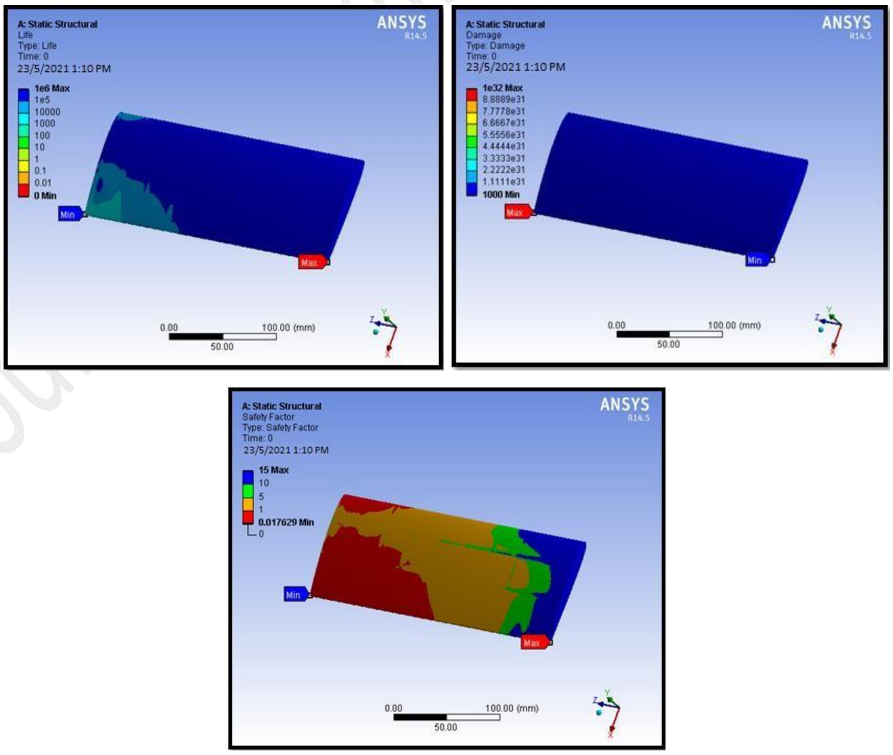

Fig.3: Life(topleft).Damage(topright).Safetyfactor (bottom).

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4. RESULTSSTATI CANALYSIS

Material	Deformation(mm)	Stress(MPa)	strain
aluminum6061-T8	0.034562	83.399	0.0012383
s2 glass	0.027463	83.545	0.00098035
carbonfiber	1.9943e-5	48.896	0.00071355

FATIGUEANALYSIS

Material	life	damage	Safetyfactor
aluminum6061-T8	1×e6	1×e32	0.010336
s2 glass	1×e6	1×e32	0.010318
carbonfiber	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 15ribs andtwo spars with skin. Front spar having "I" section andrearsparhaving"C"section.Stressandfatigueanalysisofthewholewingsectioniscarriedouttocomputeth estressesandlife at spars and ribs due to the appliedpressu reload.

- By observing the static analysis of aircraft wing, the stress values are increases by increasingthe speed of theaircraft wing, the less stress value for carbon epoxy than s2-glass andaluminum alloy 6061-T8. Carbon epoxy material has more strength because it is a compositematerial.
- By observing the modal analysis of aircraft wing, the deformation and frequency values aremore for carbon epoxy material. By observing the fatigue analysis of aircraft wing, the safetyfactorvalue is more for carbon epoxymaterial.
- So, it can be concluded, the carbon epoxy materialis better material for aircraft wing.

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