STATIC AND FRACTURE ANALYSIS FOR AIRCRAFT FUSELAGE AND WING JOINT WITH COMPOSITE MATERIAL

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Abstract: *Fracture mechanics provides a methodology for prediction, prevention and control of fracture in materials, components, and structures. Fracture mechanics analysis is the backbone of damage tolerant design. Objectives of fracture mechanics analysis are: (1) stress analysis of cracks to derive crack tip stress field equations and define crack tip stress intensity factors, (2) determination of SIF solutions as function of crack length, orientation and applied loads for a given geometry, (3) prediction of mixed mode fracture under static, dynamic, and sustained loads, (4) prediction of residual strength as a function of crack length. The focus of this paper is on fracture mechanics analysis of longitudinaland circumferential joints of aircraft fuselage structure with cracks. The loading is by internal pressure. Commercial FEA software ANSYS and a special purpose post-processing subprogram called 3MBSIF are used to determine mixed mode membrane and bending SIF solutions. Residual strength prediction is based on the use of strain energy density theory of fracture. Significant results of this study are graphically presented and discussed in this paper.*

Finally we have represented the fatigue life with the help of Goodman Curve. The Structural Component is designed and analysed using CREO and ANSYS Softwares. In analysis the maximum stress at which the component undergoes degradation/damage is calculated for different End Conditions (loadings and stresses), which determines the fatigue life of the component.

Keywords: Wing joint, Fatigue crack growth life

1. INTRODUCTION TO FUSELAGE

The body is Associate in Nursing aircraft's main body section. It holds crew, passengers, and cargo. In single-engine craft it'll typically contain Associate in Nursing engine, as well, though in some airplane the one engine is mounted on a pylon connected to the body, that successively is employed as a floating hull. The body conjointly serves to position management and stabilization surfaces in specific relationships to lifting surfaces that is needed for craft stability and maneuverability.

1.1 Types of structures

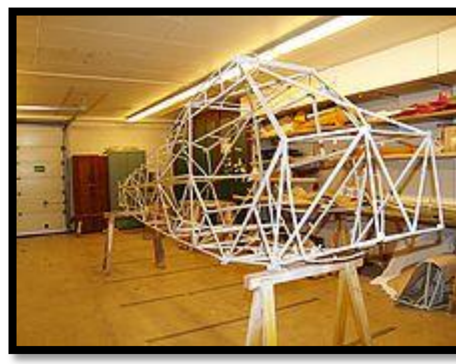

Fig1:-Piper PA-18 welded tube truss fuselage structure

1.2 Semi-monocoque

Fig2 :-Sectioned fuselage showing frames, stringers and skin all made of aluminum

This is the well-liked methodology of constructing AN all-aluminum body. First, a series of frames within the form of the body cross sections are command in position on a rigid fixture. These frames are then joined with light-weight longitudinal parts known as stringers. These are successively coated with a skin of sheet Al, hooked up by fascinating or by bonding with special adhesives. The fixture is then disassembled and faraway from the finished body shell, that is then fitted out with wiring, controls, and interior instrumentality like seats and baggage bins. Most up-to-date massive craft are engineered exploitation this system, however use many massive sections created during this fashion then joined with fasteners to create the whole body. Because the accuracy of the ultimate product is decided mostly by the pricey fixture, this kind is appropriate for series production, wherever an oversized range of identical craft is to be created. Early samples of this kind embrace the Stephen A. Douglas craft DC-2 and DC-3 civil craft and therefore the Boeing B-17 Flying defensive structure. Most metal lightweight craft are created exploitation this method.

1.3 Materials

Early craft were created of wood frames lined in material. As monoplanes became well-liked, metal frames improved the strength, that eventually crystal rectifier to all-metal-structure craft, with metal covering for all its exterior surfaces - this was 1st pioneered within the last half of 1915. Some trendy craft area unit created with composite materials for major management surfaces, wings, or the complete body like the Boeing 787. On the 787, it makes potential higher pressurization levels and bigger windows for traveller comfort further as lower weight to cut back operative prices. The Boeing 787 weighs 1500 pounds unit but if it were Associate in Nursing all-aluminum assembly.

1.4 Wing Joint

1.4.1 Wing root

The wing root is that a part of the wing on a fixed-wing craft that's nearest to the body. On a straightforward plane configuration, this can be typically straightforward to spot. On sunshade wing or multiple boom craft, the wing might not have a transparent root space.

Wing roots typically bear the very best bending forces on the wing and through landing, and that they usually have fairings (often named "wing fillets") to scale back interference drag between the wing and also the body.

The opposite finish of a wing from the wing root is that the wing tip.

1.5 Folding wing

A folding wing may be a wing configuration style feature of craft to avoid wasting area, and is typical of carrier-based craft that operate from the restricted deck area of craft carriers. The folding permits the craft to occupy less area in a very confined repair shed as a result of the sunburst wing ordinarily rises over the body decreasing the ground space of the craft. Vertical clearance is additionally restricted in combat ship repair shed decks. So as to accommodate for this, some craft like the super marine ocean hearth and Fairey pelican form seabird have further hinges to fold the wingtips downward, whereas others like the S-3 Norse have folding tails.

Short Brothers, the world's 1st craft manufacturer, developed and proprietary folding wing mechanisms for aeroplane ship-borne craft like their Short Folder, the primary patent being granted in 1913. The Folder's aeroplane wings were hinged so they closed back horizontally aboard the body, typically being command in situ by latches protrusive sideways from the rear of the body.

Fig3:-Douglas Sky raider

A folding wing has some disadvantages compared to a hard and fast wing. It's heavier and has additional advanced connections for electrical, fuel, mechanics and structural systems.

Fig4:-Comparison of the Grumman F4F Wildcat between folded and unfolded wings.

1.6 Rib

In An craft, ribs are forming components of the structure of a wing, particularly in ancient construction. By analogy with the anatomical definition of "rib", the ribs attach to the most spar, and by being perennial at frequent intervals, type a skeletal form for the wing. Sometimes ribs incorporate the device form of the wing, and therefore the skin adopts this form once stretched over the ribs

Fig5:-Wing ribs of a de Havilland DH.60 Moth

1.7 WING ATTACHMENT TO THE FUSELAGE

The wing enclose the wings is additionally a box-like structure made from ribs and spars, however it's long and skinny, and therefore perhaps appearance a bit less “boxlike” and a lot of sort of a beam. Generally such structures area unit known as “box beams”.

If one will a research on “center wing box” and takes a appearance at the pictures ensuing from the search, there'll be variety of images that look one thing just like the one below.

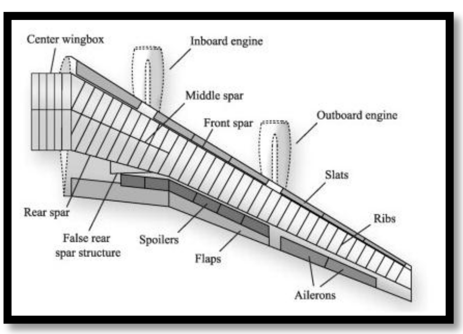

Fig6: wing attachment

When the wing-wing boxes are hooked up to the present center wing box, what's fashioned is basically one long, terribly sturdy, “box beam” that goes from wingtip to wingtip. The wing “beam” assembly then solely has to be hooked up firmly to the body in order that it does not fall off. Engines are hooked up firmly in order that they don’t fall.

2. INTRODUCTION TO CREO

PTC Creo, earlier known as CREO& Wildfire, is a 3D CAD/CAM/ CAE and associative solid modeling application. Creo is one of a suite of 10 synergistic applications that give solid, assembly modeling, 2D orthographic perspectives, FEA, parametric and direct modeling, NURBS &sub-divisional surface modeling, and functionality of NC & tooling for mechanical designers. Creo Elements/Parametric contend specifically with CATIA, NX, Solid Edge&Solidworks. It was made by Parametric Technology Corporation (PTC) &s was the first of its kind to advertise.

Creo Elements/Pro (in the past CREO), PTC's parametric, incorporated 3D CAD/CAM/CAE arrangement, is utilized by discrete makers for mechanical building, plan and assembling.

3. INTROCUCTION TO FEA

The FEM (Finite Element Method), is a numerical technique for solvingmathematical physics and engineering problems. Normal problems of areas of interest incorporate structural analysis, thermal analysis, mass transport, electromagnetic potential and fluid flow. These problems analytical solutions require the answer for limit esteem issues for partial differential conditions. The FEM definition of the issue results in an arrangement of algebraic equations. The strategy yields rough estimations of the questions at discrete number of focuses over the domain. To tackle the issue, it subdivides a huge problem into littler, more straightforward parts which are known as finite elements. These simple equations that model these finite elements are then collected into a bigger arrangement of conditions that models the whole issue. FEM at that point utilizes variational techniques from the math of varieties to inexact an answer by limiting a related mistake work.

Examining or phenomenon analyzation with FEM is frequently alluded to Finite Element Analysis (FEA).

4. FLUENT FLOW

Fluent takes into account analysis of fluid flow of compressible and incompressible fluid flow and transfer of heat u complex geometries. You indicate the computational models, boundary conditions, materials, & solution parameters, where the cases are unraveled in Fluent. You can utilize a Fluent fluid flow analysis for applying mesh to a geometry inside Workbench, at that point utilize Fluent to characterize relevant mathematical models (for example, high speed, low-speed, turbulent, laminar, and so forth.), select materials, characterize boundary conditions, and indicate solution controls that best speak to the issue to be explained. Fluent comprehends the mathematical equations, and the aftereffects of the analysis can be shown in Fluent or in CFD-Post for advance examination (e.g. vectors, contours and so on.).

5. LITERATURE REVIEW

Shashikumar.C, Nagesh.N, Ganesh [1], the aircraft needs to execute complicated maneuvers while fighting with enemies. Complicated maneuvers will require instant change in acceleration. The combination of high level of acceleration and complicated maneuvers will introduce high magnitude of loads on the wings. Normally the fighter aircraft will have wing-fuselage attachments at more than one location. Rarely an aircraft will fail due to a static overload during its service life. For the continued airworthiness of an aircraft during its entire economic service life, fatigue and damage tolerance design, analysis, testing and service experience correlation play a pivotal role. In the current project, an attempt will be made to predict the fatigue life of wing-fuselage attachment bracket in a fighter airframe. **Madiha Khan, Mohammed Rehman Khan, D. Smitha[2],** These are the most important cases of forces while studying about the Wing to Fuselage lug attachment connections. Rarely an aircraft will fail due to a static overload during its service life. Fatigue life calculation will be carried out for typical service loading condition using constant amplitude Stress-No. of cycles(S-N) data for various stress ratios. The software used are solid edge V19 for modeling lug and MSC Patran and Nastran for detail analysis.

T. NarendiranathBabu, E. Raj Kumar, R. Mageshvaran[3], A fatigue crack will appear at the location of high tensile stress in an airframe structure. Further these locations are invariably the sites of high stress concentration were studied. The life prediction of structural members are requires a model for fatigue damage build up. The stress life curve data for various stress ratios and local stress analysis was calculated to find the stress concentration. The response plots of the splice joint aircraft structure were estimated. The splice joint is one of the critical locations where fatigue crack starts to initiate. In this work estimation of fatigue life for crack initiation of splice joint structure were carried out at maximum stress location. **N. Bhaskara Rao, K. Sambasiva Rao [4],** Brackets are connexion sort components wide used as structural supports for pin connections in framing structure. During this project an in depth Finite part analysis of the body attachment below the worst loading condition was administrated. Throughout the part of project a dynamic and fatigue analysis of bracket was administrated exploitation finite part analysis package. Then the 3D model of bracket in-built NX CAD is foreign into ANSYS exploitation the parasolid format.

6. MODELING OF WING AND FUSELAGE JOINT IN CREO 2.0

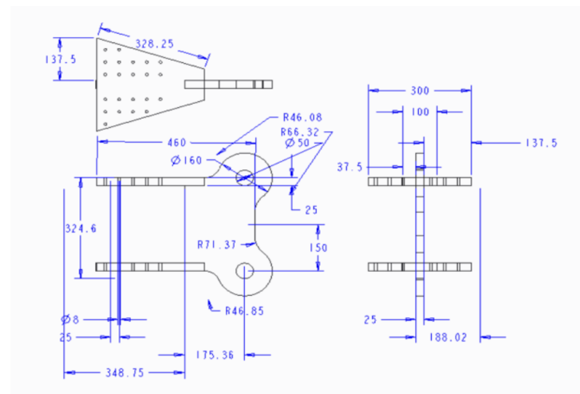

Fig7: 2-D views of the wing- fuselage attachment bracket.

7. ANALYSIS OF FUSELAGE AND WING JOINT

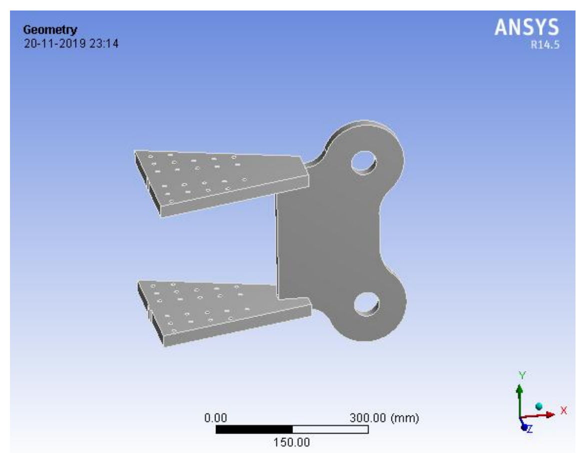

Fig8 – Imported model of wing jointfrom Creo 2.0

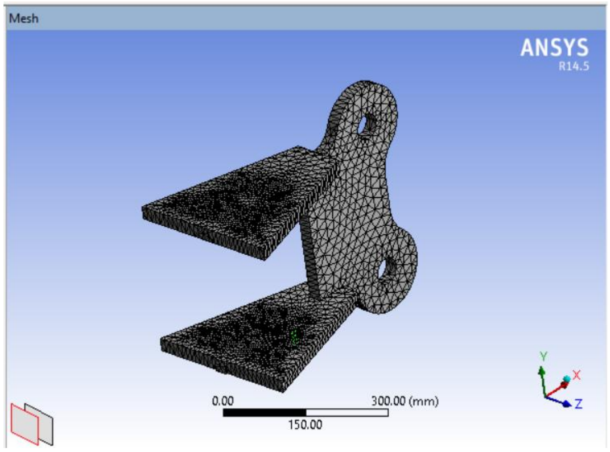

Fig9 – Meshed model of wing joint

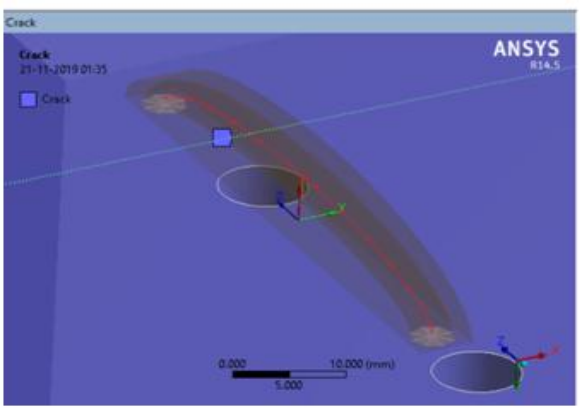

Fig10 – Crack

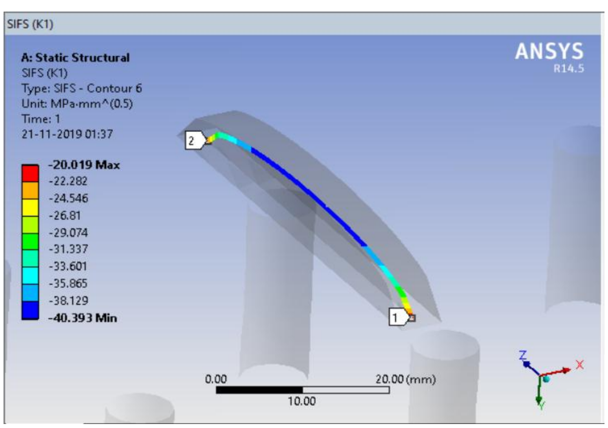

Fig 11- Stress intensity factor K1 on wing jointusing Kevlar

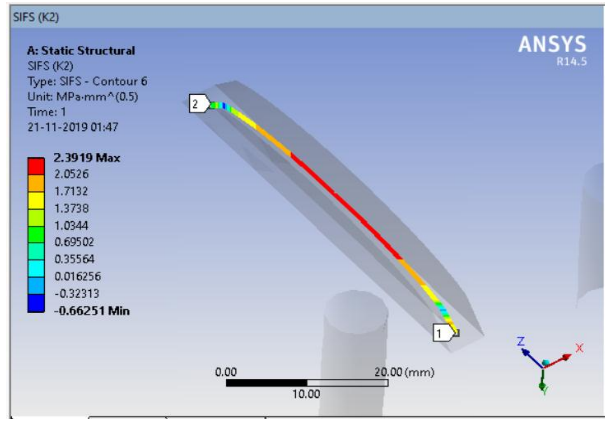

Fig12 - Stress intensity factor K2 on wing jointusing Kevlar

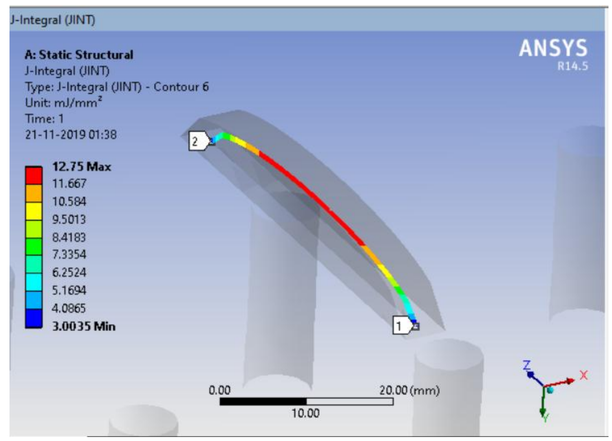

Fig 13– J – Integral on wing jointusing Kevlar

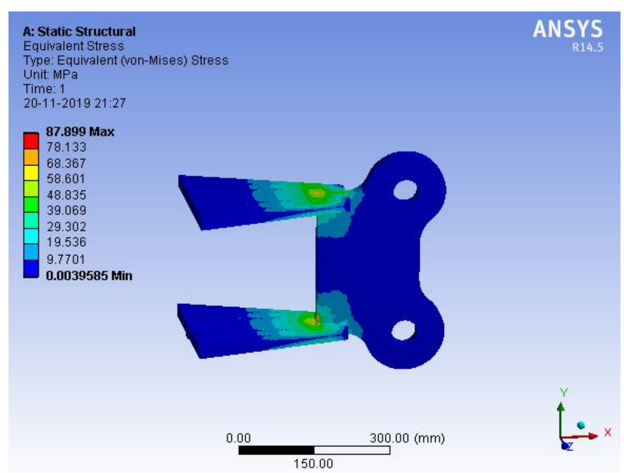

Fig 14– Equivalent Von-Mises Stress of wing jointusing Kevlar

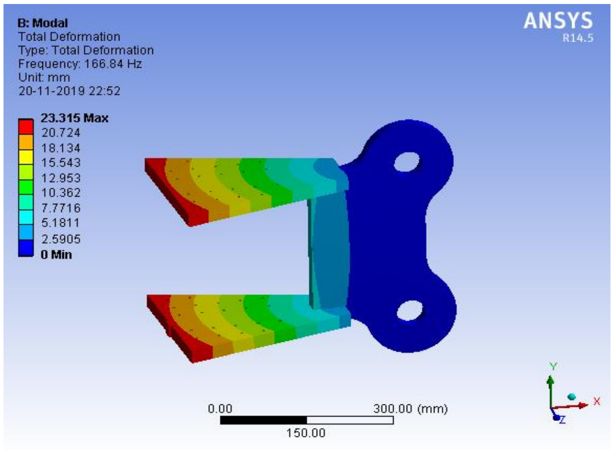

Fig15: Mode 1of wing jointusing Kevlar

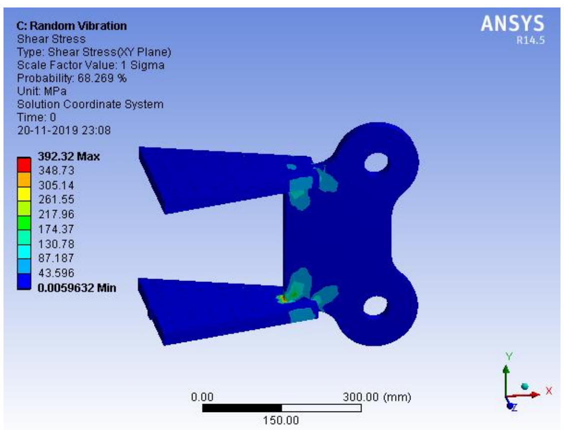

Fig16 – Shear Stress for Kevlar

8. RESULTS AND DISCUSSIONS

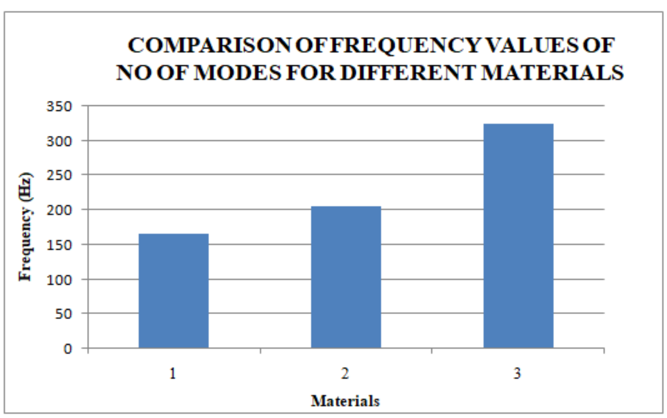

Fig17: – Comparison of Frequency values of no of modes for different materials.

From the above graph it is observed that the Frequency value is increasing by about 320% at Mode 3 of wing joint when compared with remaining Modes.

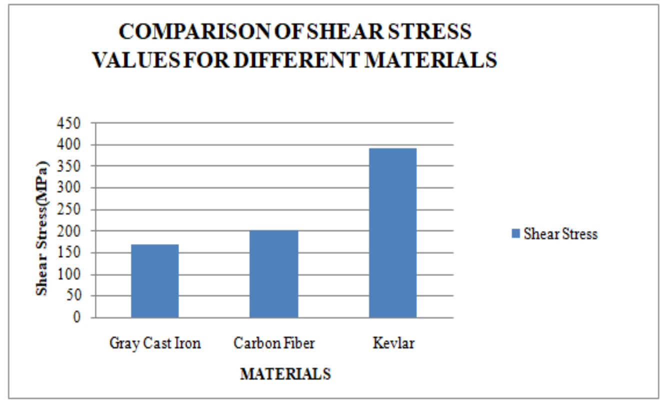

Fig18: Comparison of Shear Stress values for different materials.

From the above graph it is observed that the Shear Stress value is increasing by about 359% for Kevlar material of wing joint when compared with gray cast iron and Carbon fiber.

9. CONCLUSIONS

By observing Structural Analysis, the Stresses are increasing by about 89.858% for Carbon fiber material when compared with Kevlar and Gray Cast Iron materials. The Deformation are decreasing by about 1.0281% for Kevlar material when compared with Gray Cast Iron and Carbon fiber materials.

By observing Modal Analysis, the Deformations are increasing by about 33.554 % at Mode 3 when compared with remain Modes.

By observing Random vibrational analysis, the Stress are increasing by about 392.32 % for Kevlar material when compared with Carbon Fiber and Gray Cast Iron materials. The Deformation are decreasing by about 0.37667% for Gray Cast Iron material when compared with Kevlar and Carbon fiber materials.

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