FEA Based Analysis of Composite Torque Link for a Passenger Aircraft Landing Gear

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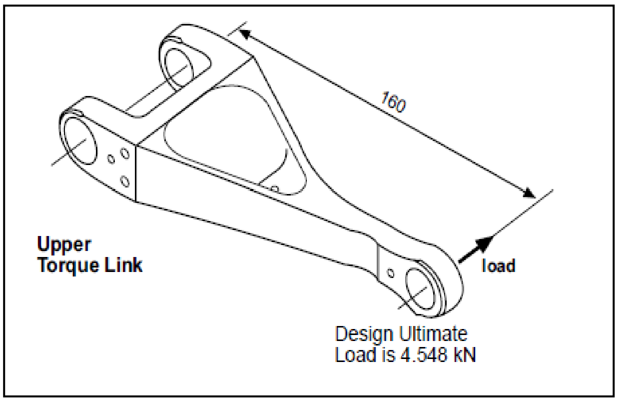
Abstract – **In the implementation of a composite landing gear technology program was started, a composite torque link for transport airplane landing gear applications was developed. The torque link was designed by finite element analysis and analysis for maximum stress condition. The torque link was fabricated by Resin Transfer Moulding (RTM) for which a tooling concept was developed. Static tests demonstrated the load carrying capabilities in undamaged and damaged condition of the torque link since all specimens failed beyond their Design Ultimate Load level for that case we are hereby carryout the analysis process in order to find the ultimate load and yield stress for the torque link.**

Keywords* – *Carbon Fiber, Kevlar, Torque Link, Optimization, FEA Analysis

I. INTRODUCTION

Torque links are one of the major components of landing gear, which take more impact loading during landing. For that case, we are planning to re-design the torque link by replacing materials (i.e., Structural Steel) to the composite materials. Composites are being used increasingly for new structural concepts for the aerospace industry. One of the reasons for using composites instead of traditional metals in these structures, besides a reduction in weight, is the potential to reduce the total life cycle costs of the structure. In order to achieve this cost reduction, new and cost effective fabrication techniques are being developed. One of these new fabrication techniques is Resin Transfer Moulding (RTM). The RTM fabrication technique is based on the injection of resin into a mould cavity that contains an assembly of dry fibres (perform). RTM has been in use within the automotive and sports industry for many years. However, now that high quality RTM resins have become available, the use of RTM as fabrication technique for structural components for the aerospace industry is increasing gradually. The main improvement of these resins, besides their improved mechanical properties, is that they have a low viscosity for a reasonable time. This means that large products with high fibre volume fractions can be made without excessive high injection pressures. Although RTM moulds often are complex and expensive, RTM has several advantages compared to the autoclave prepregs fabrication method, which, at this moment, is the standard method used in the aerospace industry.



II. MATERIALS USED FOR THE COMPOSITE TORQUE LINK

The composite torque links are composed of the following materials:

Carbon-fiber-reinforced polymer or carbon-fiber-reinforced plastic (CFRP or CRP or often simply carbon fiber), is an extremely strong and light fiber-reinforced polymer which contains carbon fibers. The polymer is most often epoxy, but other polymers, such as polyester, vinyl ester or nylon, are sometimes used. The composite may contain other fibers, such as Kevlar, aluminium, or glass fibers, as well as carbon fiber. The strongest and most expensive of these additives, carbon nanotubes, are contained in some primarily polymer baseball bats, car parts and even golf clubs [1] where economically viable.

Although carbon fiber can be relatively expensive, it has many applications in aerospace and automotive fields, such as Formula One.

The material is also referred to as graphite-reinforced polymer or graphite fiber-Reinforced polymer (GFRP is less common, as it clashes with glass-(fiber)-reinforced polymer). In product advertisements, it is sometimes referred to simply as graphite fiber for short. Carbon-fiber-reinforced polymers are composite materials. In this case the composite consists of two parts; a matrix and reinforcement. In CFRP the reinforcement is carbon fiber, which provides the strength. The matrix is usually a polymer resin, such as epoxy, to bind the reinforcements together. [2] Because CFRP consists of two distinct elements, the material properties depend on these two elements. The reinforcement will give the CFRP its strength and rigidity; measured by Stress (mechanics) and Elastic modulus respectively. Unlike isotropic materials like steel and aluminum, CFRP has directional strength properties. The properties of CFRP depend on the layouts of the carbon fiber and the proportion of the carbon fibers relative to the polymer. [3]

Material Properties

Material Properties of Torque link are as follows:

- Material : Kevlar 49
- Density : 0.052 lb/in^3
- Young's Modulus : 16.3×10^6 psi
- Poisson's ratio : 0.36

These material properties were used as input for finite element calculations.

III. DESIGN AND ANALYSIS OF TORQUE LINK

Design of Shackle is carried out in CATIA V5 R20. For the analysis the model of torque is imported in ANSYS 12 Workbench.

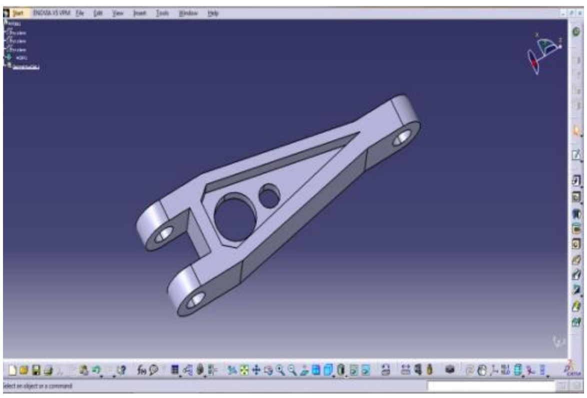


Fig. Catia V5 R20

There is certain procedure for the analysis of mechanical components. The followings are various steps involved in the analyzing of torque link.

A. Meshing of torque link

B. Boundary Condition

C. Defining the Loads

A) Meshing of torque link

For Meshing of model SOLID 185 element is used. The characteristics of meshing is as Follows

Element type	
Method of Mesh control	Hex Dominant
Size	0.0002 m
Statistics	
No. of Nodes	214498
No. of Elements	52678

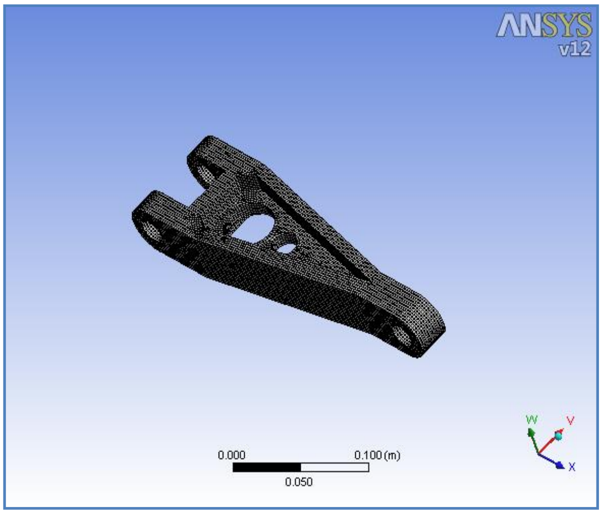


Fig. Meshing

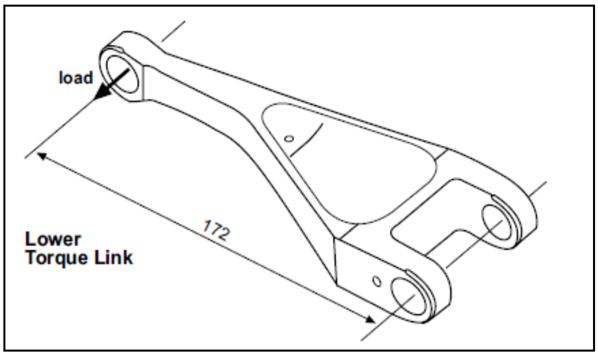
B) Boundary Condition

Torque link is subjected to loading on the both upper and lower face of the eye section of the main body as well as it is required to fix the upper face of Main pin and lower face with another torque link So that these faces can be selecting with the help of Imprint the faces option.

a) Proof Load : 100 N

b) Fixed Support: upper face of torque link

IV. RESULTS AND DISCUSSION



C) Define the Loads

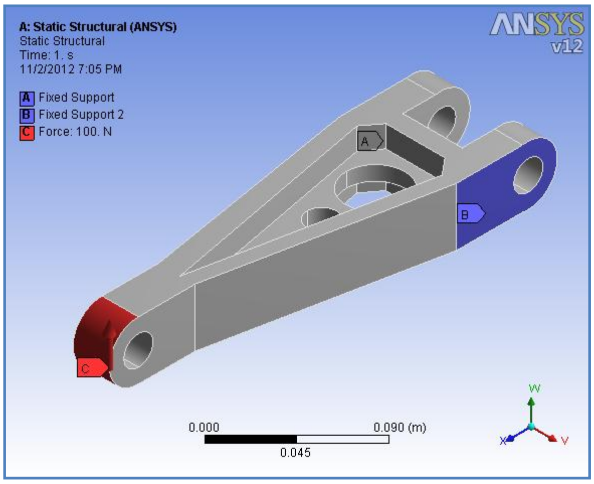


Fig. Load acting location on torque link

i) Analysis of torque link for yield stress

Due to contact of parts unavoidable stress concentration is formed hence probe values of stress as Max. Equivalent Stress (Von Mises Stress) are taken.

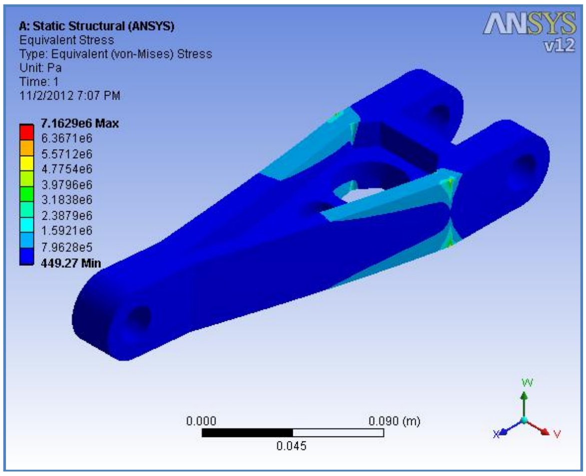


Fig. Stress contour for Proof load

Max. Eq. Stress from result: 7375 MPa

Load N	Von Mises Stress (MPa)(Probe)	Max. Deformation (m)
100	7375	0.000000999

Yield strength of torque link is just above the value of von mises stress. Hence Yield strength of torque link is 7375 MPa.

ii) Analysis of torque link for finding von mises strain

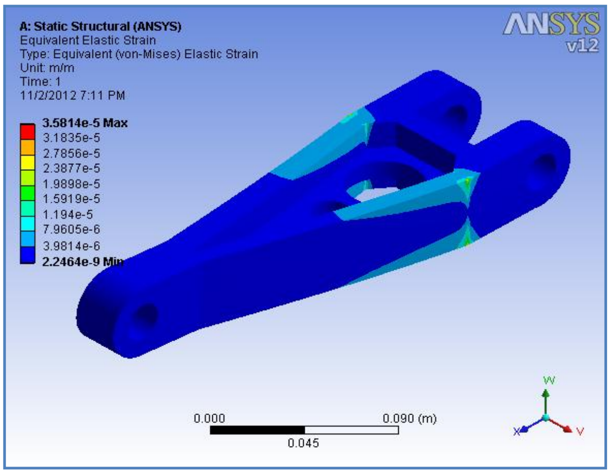


Fig. Strain Contour

Load N	Von Mises Strain (MPa)(Probe)	Max. Deformation (m)
100	0.0000656	0.000000999

iii) Analysis of torque link for finding total deformation

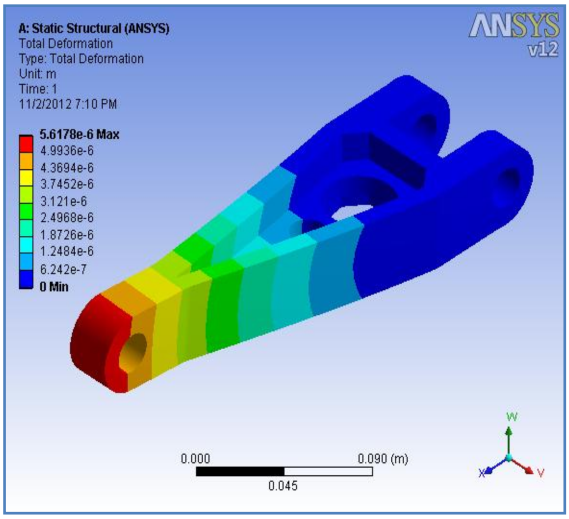


Fig . Displacement Contour

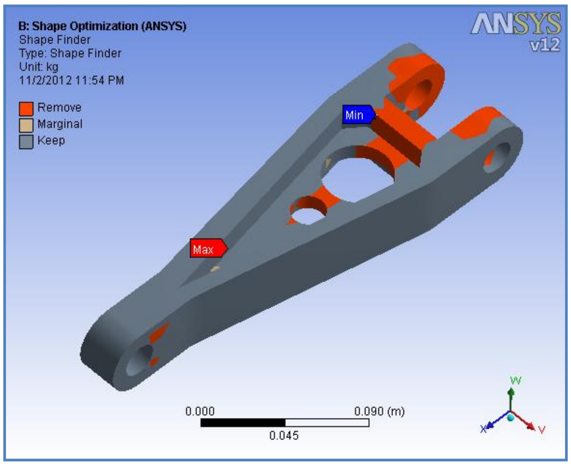
Load N	Max. Deformation (m)
100	0.000000999

COMPARATIVE STUDY

Parameters	STRUCTURAL STEEL	KEVLAR	CARBON FIBRE
Load N	100	100	100
Stress (MPa)	7160	7375	6469
Strain	0.0000358	0.0000656	0.0000924
Deformation (m)	0.000000561	0.00000999	0.0000159

From the above comparative study, our suggestion to use of Kevlar 49 composite materials will provide sufficient required result and have maximum stress value when compared to other materials.

SHAPE OPTIMIZATION



Parameters	STRUCTURAL STEEL	KEVLAR	CARBON FIBER
Original Mass kg	2.5508	0.4677	2.5634
Marginal Mass kg	0.00851	0.00142	0.00793
Optimized Mass kg	2.1659	0.39702	2.1349

From the optimization result, we are clearly expressed that use of kelvar-49 composite material will reduce the weight of the torque link as well as provide sufficient safety from the component failure and by the implementation of optimization technique, we can able to optimize 20% of its total weight of the component.

V. CONCLUSIONS

In the framework of a composite landing gear technology program a composite torque link was designed, tested and optimized using Ansys workbench V12. It is proved that all torque links failed beyond their Design Ultimate Load Level and also determine the maximum loading conditions for torque link made up of composite carbon fiber material. Therefore, the load carrying capability of the torque link was demonstrated successfully.

VI. FUTURE SCOPE

Present dissertation work covers the design and analysis, but still it has a scope for shape optimization. All components are required corrosion protection. Corrosion control is needed for all ferrous and non ferrous materials of aircraft structures by considering:

- Coatings and/or cathodic protection
- Use of a corrosion allowance
- Inspection/monitoring of corrosion
- Control of humidity for internal zones (Compartments)

VII. REFERENCES

[1] Silvio Merazzi, “Modular Finite Element Analysis Tools Applied to Problems in engineering, Ph.d These no. 1251, Ecole Polythenique Federale de Lausanne, EPFL 1994.

[2] P. Arendsen, “The B2000 Optimisation Module: B2OPT”, NLR Technical Publication 94116L, GARTEUR AG13 Structural Optimisation, March 1993.

[3] P.H.J. Vosbeek, “Analysis of Upper and Lower Composite torque link, MTR9803, May 1998.

[4] H.G.S.J. Thuis, “Composite torque link test specification report CODEMA composite landing gear”, NLR-CR-98083, February 1998.

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