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Fatigue Analysis of Torque Link in Landing Gear

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ABSTRACT:
One of the most serious flaws in landing gear torque links nowadays is fatigue. Because it causes a significant effect load to be disrupted. During landing, the landing gear bears the most weight. The project's major goal is to investigate the landing torque connections. Using ANSYS to create gears There are a lot of parts in landing gear. The use of materials such as structural steel has a negative impact on performance and lifespan. The torque connection The Kevlar 49 composite material is utilised to circumvent these limitations.

I. INTRODUCTION:

Landing gear is mostly utilised for landing and ground operations. A plane's landing gear serves two purposes. It does two things: first, it helps planes to land safely and effectively, and second, it supports planes when they are at rest. Landing gear is built to meet the needs of the aircraft and the nature of its job. The landing gear is the mechanism that holds an aeroplane in place on the ground and allows it to taxi, take off, and land. The landing gear absorbs the impact energy and distributes it to the surrounding attachments, allowing the landing gear to resist the ground impact force. Landing gear design criteria are included in the aircraft's overall design requirements, which also include

The requirement to build landing gear with the smallest possible weight, volume, and performance, as well as longer life and lower life cycle costs, has brought several problems to the landing gear industry. Practitioners and designers of equipment in addition, the landing gear design must be simplified. While adhering to all regulatory and safety standards, the development cycle time is cut in half. Over the years, several solutions have been created to address these design and engineering problems. Landing-gear development
Landing gear comes in 10 different configurations:

1. Single main
2. Bicycle
3. Tail-gear
4. Tricycle or nose-gear
5. Quadricycle
6. multi-bog
7. Releasable rail
8. Skid
9. Seaplane landing device
10. Human leg

TORQUE LINK:

Torque links are sometimes known as nutcrackers or scissors. In such scenario, we want to rebuild the torque link by switching from structural steel to composite materials. Composites are rapidly being employed in aircraft for innovative structural designs. Aside from weight savings, one of the reasons for utilising coposite instead of conventional metals in these constructions is the potential to lower the structure's overall life cycle cost. New and cost-effective manufacturing processes are being developed in order to accomplish this cost decrease.

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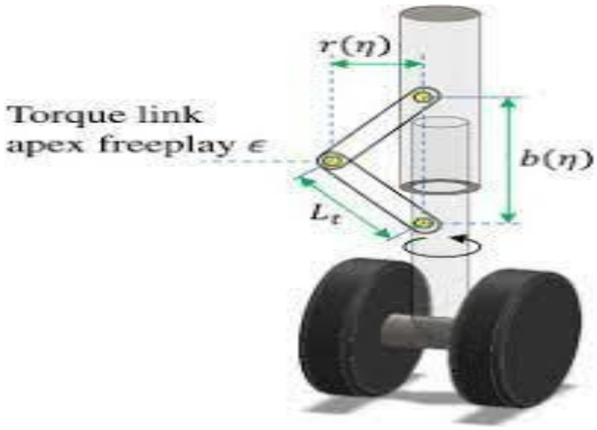
Landing gear and Torque link



COMPOSITES:

A composite material is created by fusing two or more materials, generally with highly distinct characteristics. The two materials combine to give the composite its distinct characteristics. The diverse components inside the composite, on the other hand, do not dissolve or mix into one another, making it easy to distinguish them differently. Resin transfer moulding is one of these innovative manufacturing techniques (RTM). The RTM manufacturing method is based on injecting resin into a mould cavity containing dry fibres and then assembling them (perform). RTM has long been used in the automotive and sports industries. The usage of RTM as a fabrication process for structural components in the aerospace sector is steadily growing now that high-quality RTM resins are available. Apart from their enhanced mechanical characteristics, the major advantage of these resins is that they maintain a low viscosity for a long period. This means that big products with significant fibre volume fractions may be produced without having to use excessively high injection pressures. RTM moulds, on the other hand, are frequently complicated and costly. In comparison to the autoclave prepregs fabrication process, which is now the norm in the aerospace industry, RTM provides a few benefits.

SELECTION OF COMPOSITE MATERIALS:

A material should be able to endure high temperatures, and the ideal material should be light and function well. Carbon-ceramic composites were used to meet certain needs.

Material selection is based on the several requirements

- Environment
- Stiffness
- Strength
- Coefficient of thermal expansion
- Weight
- Cost
- Machine ability

APPLICATIONS:

Carbon ceramic is a great alternative to traditional materials because of its strong resistance to tearing and wear, high mechanical strength, remarkable temperature and thermal shock stability, and low coefficient of thermal expansion.

1.Structural components with tight geometric tolerances

2.High-temperature components

3. Chemical-processing-equipment components

4. Aerospace structural components

5. Semiconductor-related components for the glass processing sector that are resistant to oxidation and thermal stress.

6. High-performance ceramics may be made in a wide range of forms and geometric patterns thanks to carbon ceramic.

7. Kevlar epoxy composites are utilised in the wing body fairing, rudder, elevator, and fixed leading

and trailing edges of the wings. The Boeing 727 uses a honeycomb sandwich panel made of Nomex and graphite epoxy.

8. The Boeing 727 uses a honeycomb sandwich panel made of Nomex and graphite epoxy.

9. Commercial aircraft have received certification for carbon-carbon composite brakes.

10. Composites are utilised in the fin and ailerons of missles.1

11. Boron epoxy was used for the fin, rudder, and stabiliser skins of the F14 and F15 (Fighters) aircraft.

12. Spacecraft dimension stability is provided via composites.

II. LITERATURE SURVEY:

Carbon fibre composites are now routinely used on the wings and fuselage of newly built aircraft. The landing gear, on the other hand, is an area of aircraft design that has eluded the composites community. Metal has typically been used in major structural elements with concentrated loads due to cautious design methods. This might change if a group of Dutch firms and scientists succeeds in designing and fabricating lightweight, long-lasting composite landing gear for helicopters and fixed-wing aircraft. SP aerospace and vehicle systems (Gel drop, The Netherlands) has been awarded a contract to design, qualify, and manufacture a retractable, crashworthy NH90 Rear Landing Gear Assembly landing gear for the NATO NH90 helicopter, in both Army (TTH) and Navy (NFH) variants.

This 10-ton-class helicopter, developed in collaboration with Euro copter (France and Germany), Augusta (Italy), and Fokker (Netherlands), will be utilised for a range of missions, including troop transport, cargo transport, and anti-submarine operations. The airframe, stabilisers, and rotor blades are all made of composites. The first serial production delivery of the helicopter is expected for 2004. Development prototypes have been flying since 1995. The NATO Helicopter Management Agency (NAHEMA), which includes France, Germany, Italy, the Netherlands, and Portugal, has placed an order for 253 helicopters, with an option for a further 124.

The Nordic nations (Sweden, Finland, and Norway) have placed an order for 52 units, with an option for further 17 units. Metal is being used for the landing gear now. According to René Heckerman, engineering manager for SP aerospace, SP aerospace began exploring the use of advanced composites in the mid-1990s in collaboration with the Structures and Materials Division of the Netherlands National Aerospace Laboratory, NLR (Amsterdam, The Netherlands), convinced that composites technology had matured to the point where a landing gear application was feasible.

The team began working on a technology development project in 1996 to design, manufacture, and verify carbon fibre composite torque links and a trailing arm assembly based on NH90 landing gear requirements. SP aerospace is the project's main firm, in charge of concept design component specifications, landing gear component integration, and component testing and validation. NLR oversees the composite elements' conceptual design, creation of design allowable, development and fabrication of the RTM production moulds and composite parts, and subsequent subcomponent testing. Two more partners contribute specialised knowledge. Euro carbon (Sitar, The Netherlands) is in charge of developing a fully automated over braiding technique for fabricating cost-effective preforms for the composite trailing arms, while MSG Software Benelux BV (Gouda, The Netherlands) is in charge of FEA of the composite structures' mechanical strength.

All-moulded composite modular panels, which include integrated skin/stringer and frame subassemblies, were determined to be the most successful idea. In comparison to current construction, these subassemblies drastically reduce the number of pieces. The subassemblies are mechanically connected enabling quick final assembly and field replacement in the case of significant damage. by the age of sixteen Science.gov is a federal government website dedicated to science (United States) M. J. Rich, G. F. Ridgley, and D. W. Lowry. 1973-01-01.

The complete text is available. A composite torque link for transport aeroplane landing gear applications was created as part of the deployment of a composite landing gear technology initiative. The torque link was developed using finite element analysis and maximum stress analysis. The torque link was created using Resin Transfer Moulding (RTM), which required the development of a tooling design. Static testing proved the torque link's load bearing capability in both undamaged and damaged conditions, and

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because all specimens failed beyond their Design Ultimate Load level, we are now carrying out the analytical procedure to determine the torque link's ultimate load and yield stress. Open Access Journal Directory (Sweden)

SCOPE OF THE PROJECT:

In order to compare the outcomes of structural steel and Kevlar 49 composite material, it was determined that the Kevlar 49 composite material has a large level of stress. In addition to strong fatigue strength, the torque links in the landing gears were designed to be lighter.

A/C NAME	TORQUE LINK WIDTH	TORQUE LINK LENGTH	TORQUE LINK INNER HOLE DIA (SMALL)	TORQUE LINK INNER HOLE DIA (LARGE)	CONNECTING HOLE DIAMETER	APEX PIN HEAD DIA	APEX PIN INNER DIA
ANTONOV AN-10	78	10	13	8	5	7	4.85
SNCASE SE161 LANGUEDOC	76	9	15	7	6	6	4.95
NORD N-262	77	11	14	7	5.5	7	4.90
MEAN VALUES	77	10	14	7	5	7	4.90

IMPLEMENTING IDEAS:

According to the journals, steel type torque links in landing gears have a lower number of stress cycles. This cycle can be lengthened by employing composite torque linkages. It can benefit by enhancing the value of stress. By substituting composite materials for steel, the stress value will be enhanced while the weight will be lowered, allowing us to build this aircraft application.

SOFTWARE REQUIREMENTS:

- Windows 8.1
- CATIA V5R18
- Gambit 2.3.16 for Meshing
- Ansys for analysis

MODELLING:

DESIGN REQUIREMENTS:

Torque Link Design

To analyse the torque connections, we must first create a three-dimensional design. We used CATIA software to develop the needed torque linkages for this project.

CATIA:

CATIA has the unique capability of not only modelling any product but also doing so in the context of its real-world behaviour. The linked world may be defined, imagined, and shaped by engineers, designers, and all other contributors. It provides a social design environment based on a single source of truth and accessible via sophisticated 3D dashboards that enable real-time concurrent design and collaboration across all stakeholders, including mobile employees. An intuitive 3D EXPERIENCE for both experienced and infrequent users, with world-class 3D modelling and simulation tools that maximise each user's performance.

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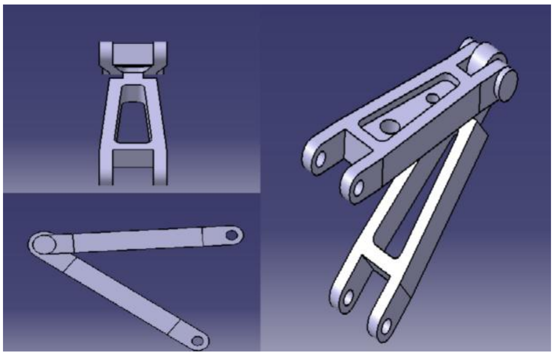

ANALYSIS:

Analysis software is a computational tool for predicting how a product will react to real-world forces, vibration, heat, fluid movement, and other physical phenomena. It determines whether a product will break, wear out, or perform as intended. It's referred to as analysis.

However, in the product development process, it is utilised to anticipate what will happen.to occur when the product is utilised This allows all the individual behaviours to be predicted. Real object behaviours
Analysis software aids in predicting the behaviour of a product as a result of a variety of physical events, including the following:

- Mechanical stress,
- Mechanical vibration,
- Fatigue,
- Motion,
- Heat transfer,
- Fluid flow
- Electrostatics,
- Plastic injection modelling

ANSYS:

ANSYS is a producer of engineering simulation software (computer-aided engineering) based in Canonsburg, Pennsylvania, United States, south of Pittsburgh. ANSYS meshing methods enable strong, well-shaped quadratic tetrahedral meshing on even the most complex geometries for solid models. A user requires little training to do complex analysis with automated contact identification and setup. Furthermore, depending on the kind of model and whether the user wants pure hex or hex-dominant mesh, users can produce pure hex meshes using one of many mesh techniques.

ANSYS mechanical, ANSYS Multiphysics, and non-commercial versions frequently used in academia are self-contained analytical tools that include pre-processing (geometry generation, meshing), Solver, and post-processing modules in a unified graphical user interface. These ANSYS Inc. Products are general-purpose finite element modelling tools for numerically addressing a wide range of physics problems, including static/dynamic structure analysis (both linear and nonlinear), heat transport, and fluid issues, as well as acoustic and electromagnetic problems.

APPLICATIONS:

Aerospace:

- Parker Aerospace use high-performance computers to get speedier simulation results.
- Carnegie Mellon University Spacecraft structural analysis and stiffness, as well as Astrobotic technology
- Roadable Terrafugia aircraft for proof-of-concept testing

PROCEDURE:

Step 1: Start the Ansys workbench.
Step 2: Create a basic geometric model.
Step 3: Create the ducted fan geometry.
Step 4: Establish the mesh border
Step 5: Make a mesh
Step 6: Establish limits
Step 7: Save the mesh
Step 8: Open the fluent interface.
Step 9: Determine the required boundary values.
Step10: Is to save the file.

MESHING:

Mesh is a discrete representation of the geometry involved in the issue in computational fluid dynamics. In essence, it allocates cells or smaller sections to which the flow must be solved. Several portions of the mesh are divided into regions with

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distinct boundary conditions. To address the problem, conditions might be used. Furthermore, meshing's applications aren't restricted to Computational fluid dynamics is a term that refers to the study It is also often used in the study of geographical and demographic data. Data on cartography Mesh may also be used to solve partial differential equations with a computer. Methods based on numbers

MESH QUALITY

The following variables can be used to make a definitive determination of mesh quality.

- Collision rate:

The higher the rate of convergence, the higher the mesh quality. It indicates that the proper solutions were found more quickly.

- Accuracy of solution:

The higher the mesh quality, the more exact the answer. To improve the mesh quality for an accurate solution, it may be necessary to refund the mesh in particular parts of the geometry where the gradients of the field whose solutions are sought are high.

- Required CPU time:

CPU time is both essential and undesired. The CPU time necessary for a highly refined mesh with the maximum number of cells per unit area will be rather big. If the CPU time required is greater, the solution obtained will be of good accuracy. However, for solutions with the same accuracy and rate of convergence, a higher CPU time needed suggests a poorer mesh quality.

SHAPES OF COMMON CELLS:

- A two-dimensional cell in its most basic form**.**

There are two typical two-dimensional cell forms. The triangle and quadrilateral are these.

- Triangle:

It has three sides and is one of the most basic mesh kinds. It's always the case.

It's simple to make and quick. Unstructured grids are the most frequent.

I. Quadrilateral:

This is a four-sided grid that is most used in structured grids.

CLASSIFICATION OF GRIDS:

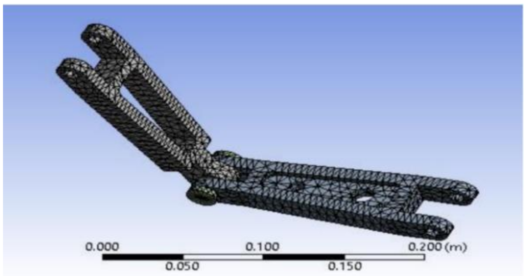
- Unstructured grid:

Unstructured grids are distinguished by their uneven connectedness. In 2D, triangles are used, while in 3D, tetrahedral grids are used.

- Hybrid grids:

A hybrid grid has both organised and unstructured areas. These grids can be non-conformal, which implies that grid lines at block borders don't have to match.

MESHING OF TORQUE LINK:



Meshing of torque link

MESH INFORMATION:

- Mesh control method

meshing of the surface (Triangle)

- Sizing:

Relevance Centre: Fine
Element size: Default
Span angle centre: Coarse
Minimum edge length:5.0mm

- Statistics:

No of nodes:11708
No of elements:5936

- Inflation:

Transition Ratio:0.272
Maximum Layer:5

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Growth rate:1.2
Inflation Option: Smooth Transition

BOUNDARY CONDITION:

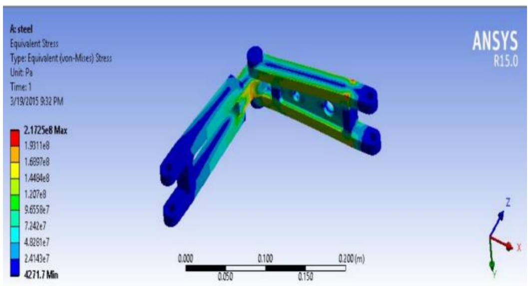
Torque Link is exposed to loading on one end of the main body and is necessary to fix the other end. These faces may be selected using the imprint the faces option.

a) Maximum load: 1000 N
b) Fixed support: Upper face of torque link.
c)Loading: Lower face of torque link.
(i)STRUCTURAL STEEL:
(ii)COMPOSITE MATERIAL (KEVLAR 49):
(ii)NICHROME(Ni-Cr)

S.NO	PROPERTIES	VALUES	UNITS
1.	Elastic Modulus	210	GPa
2.	Density	7800	Kg/m3
3.	Poisson Ratio	0.3	_

ANALYSIS:
DEFINE THE LOAD:

S.NO	PROPERTIES	VALUES	UNITS
1.	Elastic Modulus	112.38	GPa
2.	Density	1439.36	Kg/m3
3.	Poisson Ratio	0.36	_



Load acting location on torque link

In Figure,

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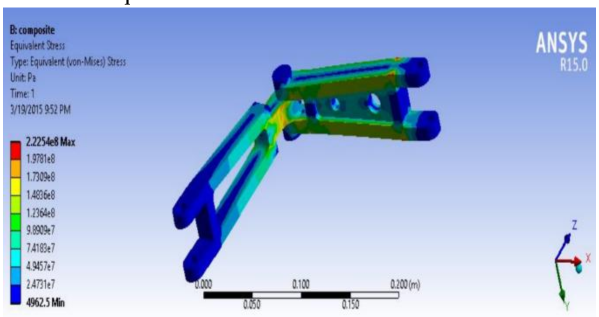
A – Fixed end
B -Load applied (1000 N)

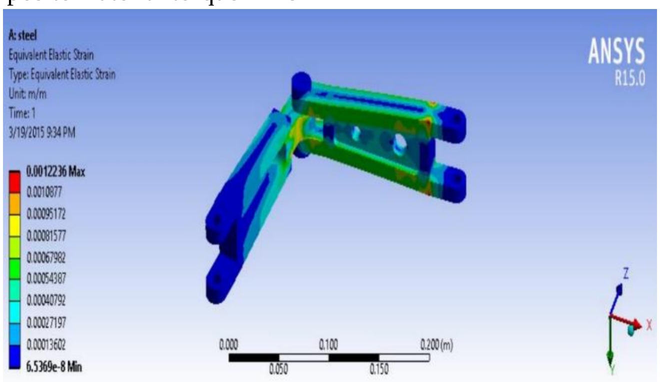
S.NO	PROPERTIES	VALUES	UNITS
1.	Elastic Modulus	150.61	GPa
2.	Density	8000	Kg/m3
3.	Poisson Ratio	0.3	_

STRESS ANALYSIS:
(I)Stress analysis for structural steel torque links



Stress analysis for structural steelFrom Fig,

MAXIMUM STRESS VALUE: 217.25 MPa
MINIMUM STRESS VALUE: 4271.7 Pa
(ii)Stress analysis for composite material torque links



Stress analysis for composite

From fig,
MAXIMUM STRESS VALUE: 222.54 MPa
MINIMUM STRESS VALUE: 4962.5 Pa
(iii)Strain analysis for structural steel material torque links

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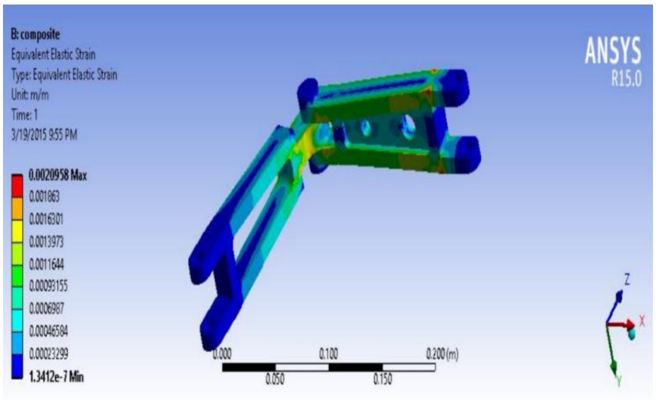
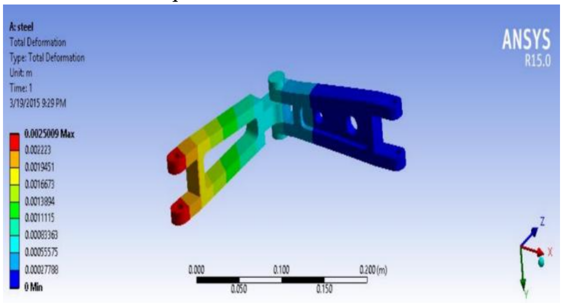


Strain analysis for structural steel

From fig,
MAXIMUM STRAIN VALUE: 0.0012236
MINIMUM STRAIN VALUE: 6.5369×10-8
(iv) Strain analysis for composite material torque links

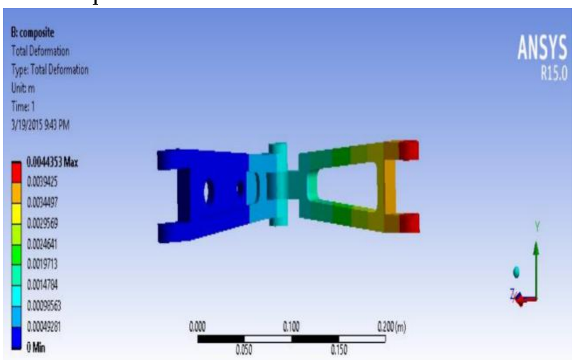


Strain analysis for composite material

From fig,
MAXIMUM STRAIN VALUE: 0.0020958
MINIMUM STRAIN VALUE: 1.3412×10-6

DEFORMATION:

(I)Deformation for structural steel torque links:



Deformation for structural steel

From fig,
MAXIMUM VALUE: 0.0025009 m
MINIMUM VALUE: 0

COMPARATIVE STUDY:

Comparison of structural steel and Composite material:

S.NO	PROPERTIES	MAXIMUM VALUE	MINIMUM VALUE	UNIT
1.	Stress	217.25×10^6	4271	Pa
2.	Strain	1.2236×10-3	6.5369×10-8	
3.	Deformation	2.5009×10-3	0	m

(I)STRUCTURAL STEEL:

COMPARATIVE STUDY:

Comparison of structural steel and Composite material:

(i)STRUCTURAL STEEL:

S.NO	PROPERTIES	MAXIMUM VALUE	MINIMUM VALUE	UNIT
1.	Stress	217.25×10^6	4271	Pa
2.	Strain	1.2236×10^-3	6.5369×10^-8	
3.	Deformation	2.5009×10^-3	**0**	m

(ii)COMPOSITE MATERIAL:

S.NO	PROPERTIES	MAXIMUM VALUE	MINIMUM VALUE	UNIT
1.	Stress	222.54×10^6	4962.5	Pa
2.	Strain	2.0958×10^-3	1.3412×10^-6	
3.	Deformation	4.4353×10^-3	**0**	m

THEORITICAL DISCUSSION:

The comparison of structural steel and Kevlar 49 composite materials is shown in the table above, as well as the behaviour of these materials when subjected to a 1000N load. Stresses and strains were introduced as a result of the load application. It The applied load, material type, and material characteristics will all influence the outcome. Stress, strain, and deformation values of structural steel and Kevlar 49 composite materials are shown in the table. According to these tables, when the same amount of load is applied to both Kevlar 49 composite materials and structural steel, the Kevlar 49 composite materials have a higher level of stress.

III. RESULT:

The performance of torque links in aeroplane landing gears is harmed by the use of traditional materials such as structural steel. It also has to deal with issues that occur over time. The introduction of Kevlar 49 composite material solves such issues.

Based on the composite study, we believe that using Kevlar 49 composite materials will offer adequate results and have the highest stress value when compared to other structural materials.

IV. APPLICATIONS:

The usage of Kevlar 49 composite material reduces the weight of the torque link, as demonstrated by the results. As a result, if the aircraft is widely used.

In addition, enough protection against component failure is required. As a result, it boosts the aircraft's performance. We can expand the use of aeroplane landing gears by employing the Kevlar 49 composite material.

V. FUTURE SCOPE:

Although the current dissertation work focuses on design and analysis, there is still room for form improvement.

In comparison to other materials, composite materials have a lower weight.

As a result, the torque link's weight will be reduced by using a composite material (Kevlar 49). Composite materials will provide sufficient fatigue and fracture resistance in the future.

Corrosion protection is necessary for all components since corrosion management is required for all types of materials. It might be ferrous or nonferrous in nature. Corrosive resistance of composite materials is higher than that of steel.

Controlling corrosion in aircraft structures by taking into account

- Coating anode or cathodic protection.
- Use of corrosion allowance.
- Inspection or monitoring of corrosion.

VI. CONCLUSION:

As a result of the use of traditional structural steel torque links in landing gears, there is an issue with overall performance and torque link weight. The usage of Kevlar 49 composite material alleviates these limitations. It outperforms standard structural steel in terms of performance.

As a result, structural steel can be replaced to reduce weight, improve performance, increase fatigue strength, load bearing capacity, and longevity.

CATIA V5R18 was used to design it, while ANSYS was used to analyse it.

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