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Design & Optimization of Torque Links of Helicopter Landing Gear

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***Abstract*— The project overall talks about the torque links design and its optimization of helicopter landing gear. Aluminium has a density lower than those of other common metals, at approximately one third that of steel. It has a great affinity towards oxygen, and forms a protective layer of oxide on the surface when exposed to air. Some of the best properties of aluminium alloy are, light in weight, high strength to weight ratio, corrosion resistant, posses' ductility at low temperatures, resilient, heat conductive, etc. Aluminium Alloy offers a ease in wide range of assemblies, as it is easy to fabricate, cost effective, uniform quality, easy manufacturing methods, and at last we have is freedom of design while selecting aluminium as our material. The torque link was designed in NX CAD software. We decided to use NX CAD due to its easy GUI and ease of feasibility. The mass of torque links normally is of 6kg with titanium alloy. We have derived out a new design with the base material as aluminium alloy and the weight before optimization was found out to be 3.16kg. FEA was also carried out on torque links for estimation of minimum/maximum stress and strain points on the model. The optimization process was carried out in ANSYS 2022 R2, and with the optimization results, the optimized weight was found out to be 2.7kg. We achieved a 46% weight reduction difference using aluminium alloy.**

Keywords— Torque links, aluminium alloy, weight optimization

I. INTRODUCTION

A torque coupling, sometimes referred to as a torque arm or torque rod, is a mechanical part used in several machines to convey torque or rotation. Torque or rotational motion are required when resistance or control are present. The primary purpose of the torque Link's purpose is to provide stability, support, and control by limiting or controlling the motion of spinning pieces. They are mostly used in suspension, landing gear, and transmission systems. Torque links can be constructed from a variety of materials, such as composites or metal alloys, depending on their intended use. They frequently include a robust connection and can withstand huge loads.

II. OVERVIEW

The torque link was designed in NX CAD software. We decided to use NX CAD due to its easy GUI and ease of feasibility. We derived the torque link in Y-Shape as conventional shapes tend to be in Y shape due to its ease in manufacturing and cost effective. The overall advantage of Y Shape is that the structure is light in weight due to cut-out section provided in the middle. The design was thus imported in ANSYS 2022 R2 for optimization and FEA purposes. Initially 8mm thickness was given and the adjacent weight was found out to be 3.16kg. On this model, keeping the boundary conditions in mind, a quad mesh was generated. The overall optimization resulted in 46% weight savings. This will not only benefit the structure but also be considered as cost effective.

III. METHODOLOGY

Torque links made up of titanium alloy generally tend to contribute to weight as well as it contributes to the dead weight to the landing gear after take-off scenarios. Thus, by reducing the weight of the torque links, major weight savings could be implemented on the landing gear. This will not just reduce the weight but will also help in cost savings of the OEMs. Generally, as aluminium is the standard material in the aerospace industry, it can be used to manufacture torque link. Thus, this thesis explains a new design concept of torque link as well as FEM analysis. The maximum stresses before and after optimization are nearly same. Hence, it is proved in this thesis that changing the material and obtaining the change in weight, gives the same FEM results which are obtained before optimization process.

A. DESIGN

Generally due to space constraints near the wheel well of the helicopter, we derived out a Y-Shaped torque link and essentially made a hollow portion to reduce the overall weight of the model. Below figure demonstrates the torque link design.

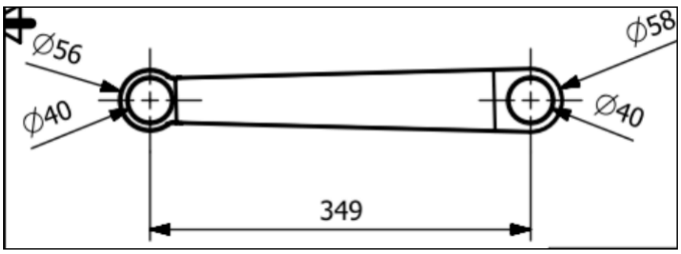

Figure 1: Front View of Torque Link

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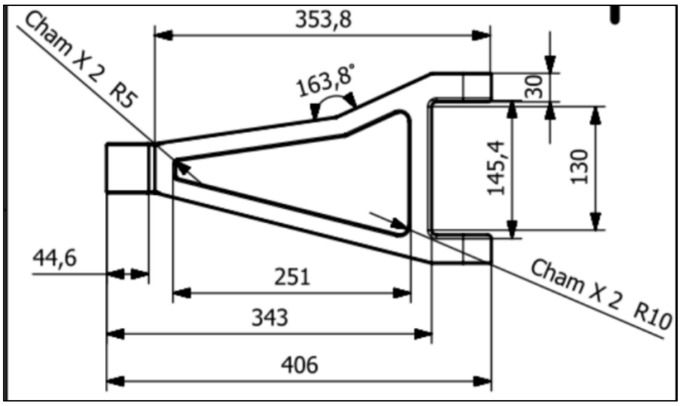

Figure 2: Torque Link Dimensions

B. FINITE ELEMENT ANALYSIS(FEA)

A computational technique called finite element analysis (FEA) is used to examine how structures or systems behave and perform in different stresses and situations. It is commonly used to simulate and comprehend the behaviour of complex systems in engineering and scientific disciplines.

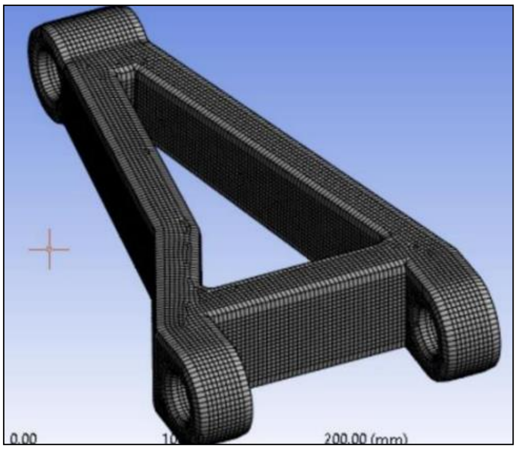

Figure 3 : Meshing of Torque Link

A hexahedral grid, also known as a hexagonal grid or brick grid, is a grid used in numerical simulation and modeling. It is a 3D mesh containing hexahedral elements, which are rectangular geometric shapes. Adaptation of hexahedral mesh was intended due to its great efficiency over the computation time. Hexahedral mesh generally forms lesser nodes as if compared with tetrahedron mesh. Hence, to save the computation time and eventually generate efficient results.

C. RESULTS

We tested the torque link under the static condition, with fixed supports at the two holes provided in the front and major load bearing part being the hole situated at the end. The image provided below shows the boundary conditions applied to the model. To calculate load, maximum take-off weight has to be taken in considerations. Factor of Safety(FOS) is also induced.

MTOW = 15000kg
As the nose landing gear receives 5% of weight during landing, hence weight on nose landing is-
Weight of Nose landing gear = 750kg = 750*9.81 = 7357.5 N

FOS is taken as 1.3, because majorly landing gear components in aerospace industry have a FOS of 1.2-1.3 Therefore, total weight of landing component will be,
Total weight = Weight on nose landing gear*FOS = 7375.5*1.3 = 9564.5N of which approximate 9.5kN.
The material provided was Al 6061 alloy. The desired maximum stress and strain contours were obtained.

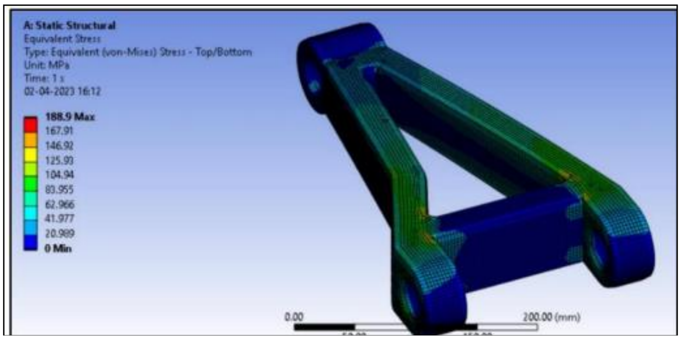

Figure 4: Maximum Stress Contour for Torque Link

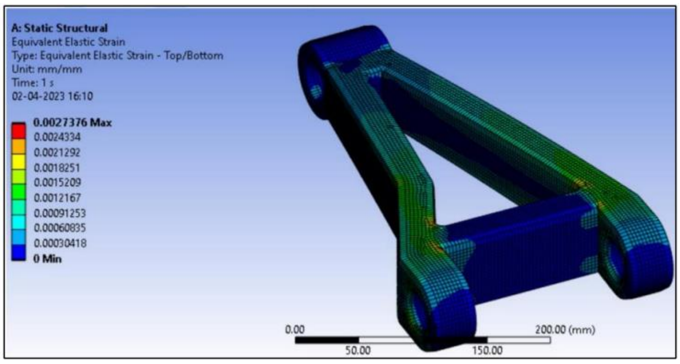

Figure 5: Maximum Strain Contour for Torque Link

TABLE I: Aluminium 6061 Case Results before optimization

Maximum Stress	188.9 MPa
Maximum Strain	0.0027376
Factor of Safety	1.48
Mass	3.16kg

The model hence was taken through optimization process wherein mass was reduced based upon the parameters which were evaluated like thickness, factor of safety, etc. The software’s optimization tool is an efficient workbench to optimize models. The optimization results are thus shown below.

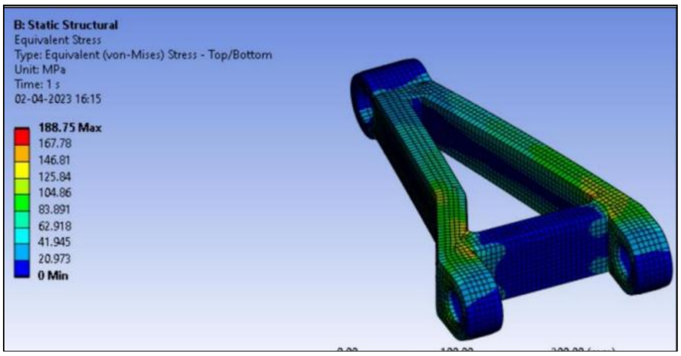

Figure 6: Maximum Stress Contour

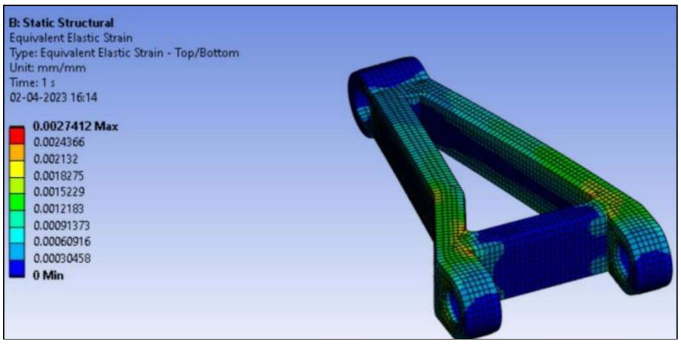

Figure 7: Maximum Strain Contour

TABLE II: Aluminium 6061 Case Results after optimization

Maximum Stress	188.75 MPa
Maximum Strain	0.0027412
Factor of Safety	1.24
Mass	2.7kg

D. PERCENTAGE CALCULATION:

Weight obtained before optimization (W1) = 3.16kg

Weight obtained after optimization (W2) = 2.7kg

Weight Difference = W1-W2 = 3.16-2.7 = 0.46

Percentage Weight Reduction = 0.46*100 = 46%

In case of aluminium, an overall 46% weight reduction is achieved.

CONCLUSION

The Landing Gear contribute to a larger dead weight after the take-off conditions. Torque links which are provided in the landing gear to resist the twisting of oleo struts also result in higher weight contributions. Thus, by reducing the weight of torque link can contribute to efficient weight savings. Normally, torque links are made up of titanium for aircraft and few helicopter applications. We have used aluminium alloy 6061-T6 grade which has a tensile strength of 310MPa. Hence, we analyzed our designed torque link on the extreme loading conditions of 9.5kN as per the calculations. The results which we obtained before optimization process was maximum stress as 188.9 MPa, strain as 0.0027376 and factor of safety as 1.48, with weight as 3.16kg. The results after optimization resulted as maximum stress as 188.75 MPa, strain as 0.0027412, factor of safety as 1.2, with weight 2.7kg. The percentage weight reduction is nearly 46%. But as of for civil applications, we could also use aluminium torque links for specially designed private VIP helicopters and other small scale cargo helicopters.

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