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Design and analysis of aircraft landing gear axle

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ABSTRACT

The Aircraft Landing Gear supports the entire weight of the Aircraft during Landing and ground operations. They are attached to primary structural members of the aircraft. The type of gear depends on the aircraft design and its intended use. Most landing Gear have wheels to facilitate operation to and from hard surfaces, such as airport runways. Our project mainly aims in designing and analysis of Landing gear Axle for 1.25 tonne, SWIFT type, UAV (Unmanned Aerial Vehicle), this project was conducted under the guidance of DRDO (Defense Research and Development organization). Other Gear feature skids for this purpose, such as those found on Helicopters, Balloon gondolas and in the tail area of some tail dagger aircraft.

In the design and analysis of landing gear axle, the wheels of the aircraft are attached to the bearings which are in turn attached to the axle, when in turn supports the entire wheel system and absorbs the impact while touching the ground. These are being designed according to FAR23 regulations.

Aircrafts that operate to and from frozen lakes and snowy areas may be equipped with landing gear that have skid, aircrafts that operate to and from the surface of water have pontoon type landing gear. This landing gear axle can be used in all types of aircrafts regardless of the landing gear, shock absorbing equipment, brakes, retraction mechanism, control, warning devices, cowling, fairings Structural members used.

Keywords: *Axle, FAR23, UAV, Drone, Landing gear, SWIFT type.*

1. INTRODUCTION

An UAV (Unmanned Aerial Vehicle) is commonly known as drone, which is an aircraft without a human pilot aboard. UAV is a component of an unmanned aircraft system (UAS), which includes the following: UAV, Ground based controller and a system of communications between the two. The flight of UAV's may operate with various degrees of autonomy which is either by remote control operation by a human operator or autonomously controlled by onboard computers. The basic four types of drones from which the most are developed from are: Fixed wing drone, Single rotor drone, Multi rotor drone and Hybrid VTOL. Some of the famous drones that are developed in India are: Rustom I, Nishant, Lakshya, Rustom II.

The main aim of this project is to alter the dimensions of the axle present in the landing gear system of an aircraft, by altering its dimensions to save space and weight, without affecting its characteristics and performance. **This project was conducted under the guidance of DRDO (Defense Research and Development Organization) situated in AVADI, Chennai.**

2. LANDING GEAR ARRANGEMENT

2.1 Landing Gear

Landing gear is a very major component in any UAV. The landing gear provides a stable support for the aircraft while resting on the ground and acts as a shock absorber while landing and absorbs a majority of impact energy dissipated. It also acts as a braking system during the motion of the UAV on the runway. The types of Landing gears are arrangement are: Tail wheel type, Tandem type,

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Tricycle type. The designed axle shaft is compartable only with Tricycle type landing gear, which is the most commonly used type.

2.2 Tricycle type landing gear

The tricycle landing gear comprised of main gear and nose gear and this type is used on large and small aircraft which allows more force full application of the brakes, provides more visibility from the flight deck,prevents ground looping of the aircrafts and thus this type of landing gear is most commonly used. The nose gear of a few aircraft with this type of landing gear is not controllable. It simply casters as steering is accomplished with differential breaking taxi. However, nearly all aircraft have steerable nose gear. On light aircraft, the nose gear is directed through mechanical linkage to the rubber pedals. Heavy aircraft typically utilize hydraulic power to steer the nose gear. Control is achieved through an independent tiller in the flight deck.

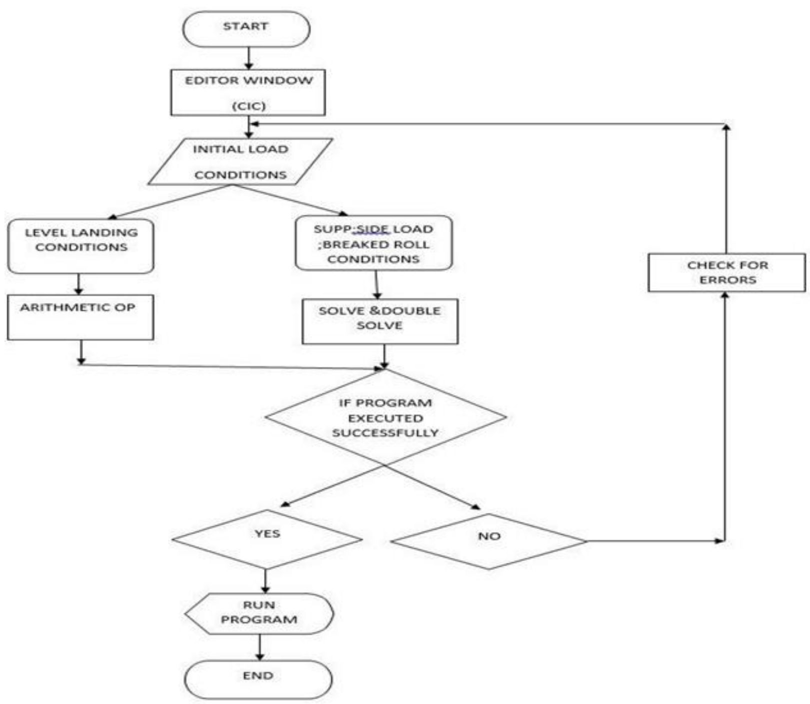
3. HOLLOW TYPE AXLE

Initially a solid axle was designed and optimized based on the provided input parameters by DRDO, but later we have also developed a hollow type axle which not only reduces material usage but also reduces the overall weight. The overall length has also been reduced so that the distance between the fork and wheel is minimized. All the necessary analysis and calculations concerning with safety and breakage were conducted and the design was optimized to retain the original characteristics of the axle and was approved by DRDO under safety and performance aspects. All the work was conducted as per the FAR23 regulations.

4. CALCULATIONS

4.1 MATLAB Calculations

MATLAB was made use of to calculate the horizontal and vertical forces, acting over the surface of the axle, a suitable structure was developed using Matlab to calculate this force. The standard input parameters for the calculations were provided by firm from their aircrafts. Once the force was calculated, it was made use of to calculate the optimum axle diameter and length. The calculations and the calculated values are provided below.



Process Flow Chart

	A	B	C	D	E	F
1	s.no	LL2PT	LL3PT	TailDown	Static	
2	MLG_V	22771.462	17084.604	22771.462	5389.6403	
3	MLG_H	8864.1320	6650.4375	0	0	
4	NLG_V	0	11373.716	0	1483.2192	
5	NLG_H	0	4427.3890	0	0	
6						
7						single whe
8						11385.731
9						4432.0660
10						

Final Calculation Results of Force

From the MATLAB Calculations, it is found that the vertical and horizontal force is, **V=44195N, H=17821N.**

4.2 Calculation of Solid Axle diameter

$$\frac{M}{I} = \frac{\sigma}{Y} = \frac{E}{R}$$

(M=Bending moment, I=second moment of aria, σ=stress, Y=distance from neutral axis, E=modulus of elasticity, R=radius of curvature)

$$\sigma = \frac{M * Y}{I} = \frac{M}{Z}$$

$$I = \frac{\pi}{64} * d^4$$

$$Y = \frac{d}{2}$$

$$Z = \frac{\frac{\pi}{64} * d^4}{\frac{d}{2}} = \frac{\pi}{32} * d^3$$

$$\frac{S_{yt}}{N} = \frac{M}{\frac{\pi}{32} d^3} = d^3 = \frac{\sqrt{(M * N * 32)}}{S_{yt} * N}$$

$$M = R * L$$

$$V = 44195\ N;$$

$$H = 17821\ N;$$

$$R = \sqrt{V^2 * H^2}$$

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R = 47652.76N;

R1 = R2 = 23826N

L = 206/2 = 103mm; length of axle

$$d^3 = \frac{\sqrt{(2454117.42 * 1.5 * 32)}}{1200 * \pi}$$

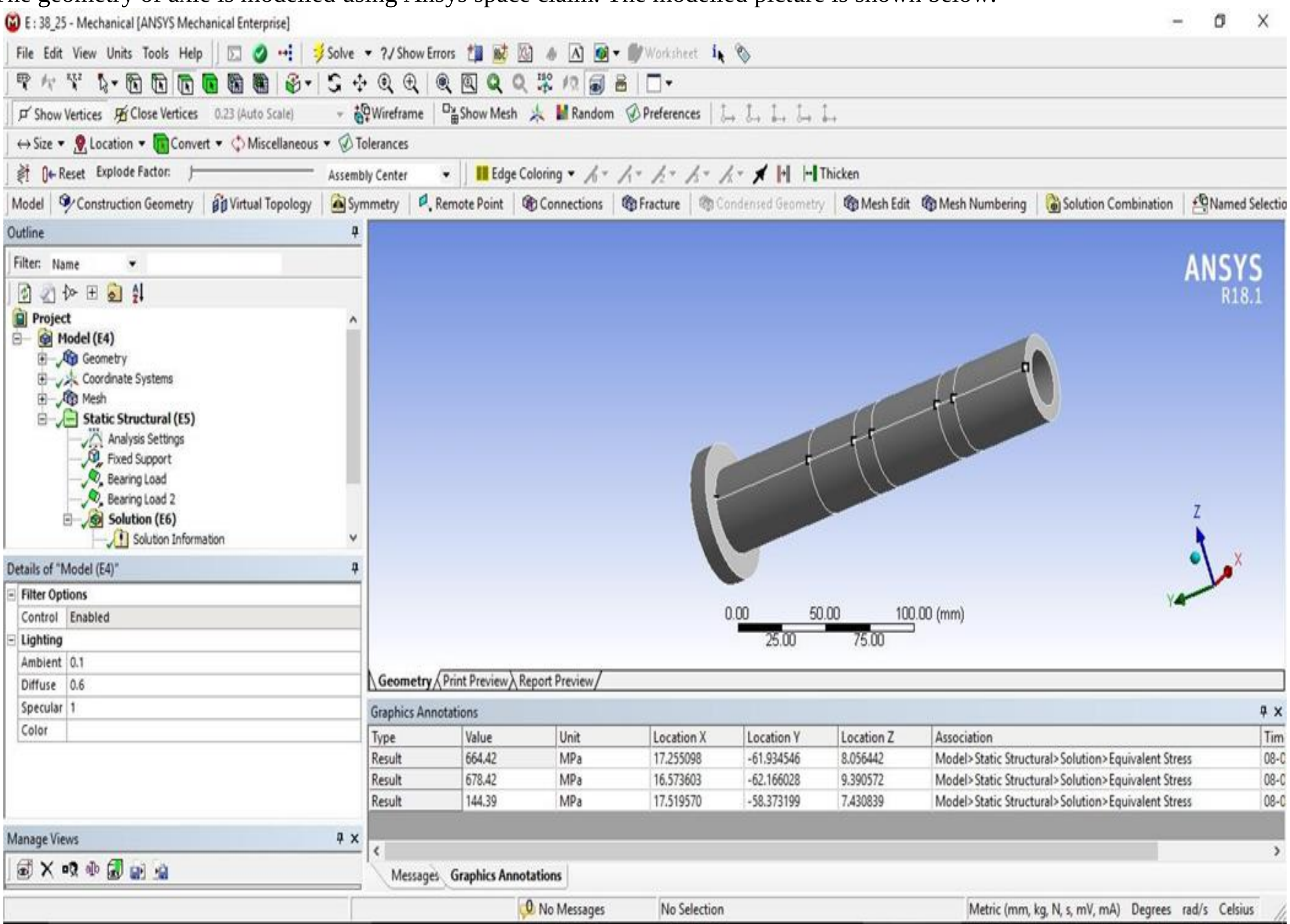
d=31.496mm; Diameter of the axle.

From the above calculations, the diameter of Solid axle is calculated as, **d = 31.496 mm**

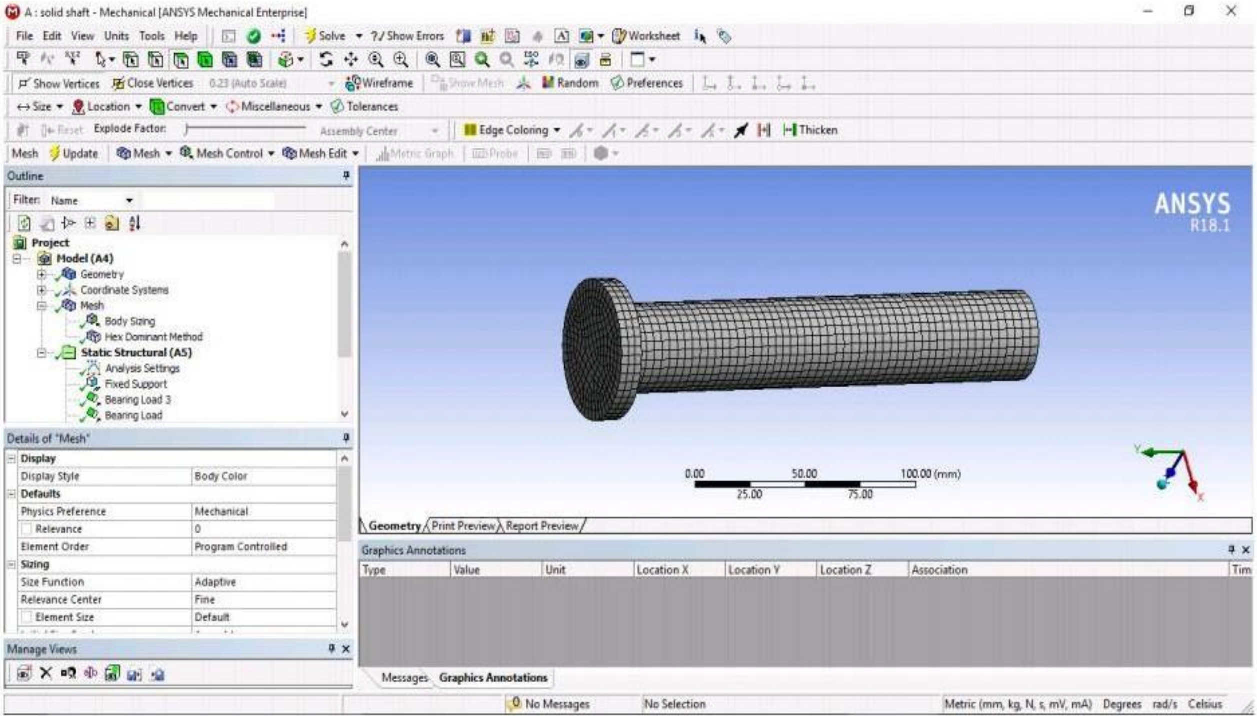
5. DESIGN AND ANALYSIS OF SOLID AND HOLLOW AXLE

5.1 Designing of Solid and hollow Axle

The geometry of axle is modelled using Ansys space claim. The modelled picture is shown below.



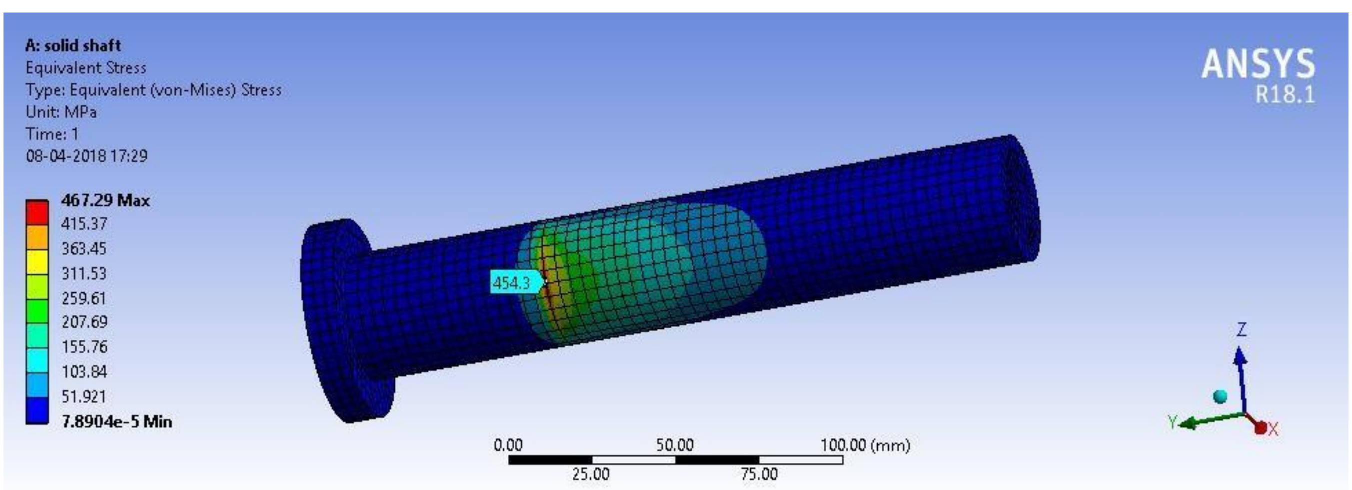
Space Claim Model of Hollow Shaft



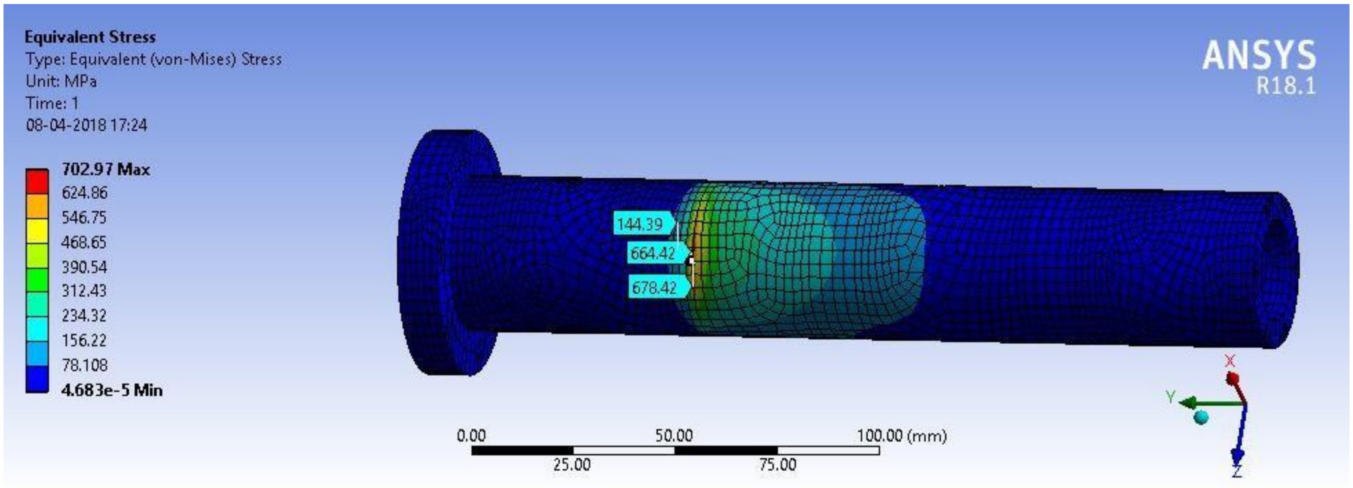
Hex Mesh Model of Solid Shaft

5.2 Analysis of Solid axle

The geometry and stiffness of axel affects the stress experienced by the fork and hence a combined analysis is to be performed for any further weight reduction studies. Since the principle stress is compressive in nature at critical location, the von-mises stress criteria is considered. The maximum non-mises in fork was increased from 302Mpa to 358Mpa which is lesser than the yield strength of the material. The reserve factor of the optimized fork is 1.2 so the axle design is safe. The maximum von-mises is axle is increased from 467Mpa to 680Mpa for all the solid and hollow axle. The reserve factor of the optimized axle is 1.5, hence the result is safe.



Analysis of Solid Axle



Analysis of Hollow Shaft

6. RESULT AND CONCLUSION

The analysis result of both solid and hollow shaft shows that they are capable of withstanding the forces and stresses which is induced in the landing system. Also the hollow shaft has also proven worth replaced as it has also been able to withstand forces with reduced material usage and weight. Thus compared with the hollow and solid shaft the hollow shaft has been facilitated for the axle design as the weight of the material is being reduced.

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