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PARAMETRIC OPTIMIZATION OF LANDING GEAR STRUT USING STATIC STRUCTURAL LOADING USING FEA

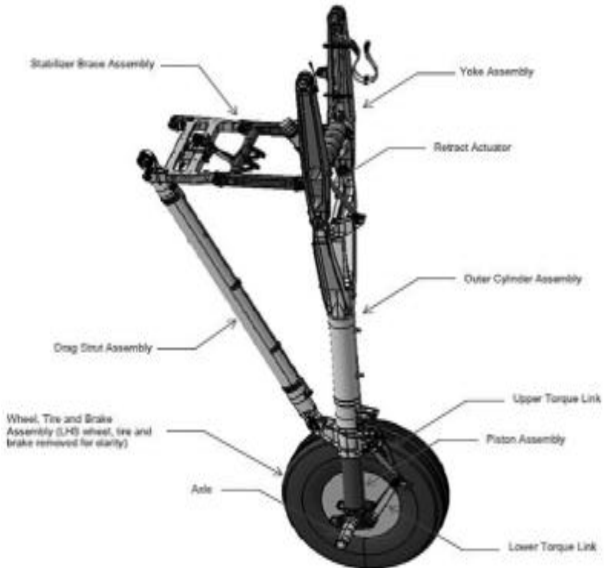
Nagahanumaiah M A[1], Mr.Pampapathi.M[2], Dr.Krishnamurthy.N[3]
Department of Mechanical Engineering, Vijaya Vittala Institute of Technology, Bangalor

ABSTRACT: This Landing gear is an important structural component in the aircraft, which is responsible for safety of passengers and payload during takeoff, landing and taxing in the ground. During landing and takeoff the impact load generated should be efficiently transferred to the respective structural component of the aircraft like bulk heads. But most of the time impact load is generated during touchdown which more than the desired due to which high stresses are developed in the landing gear components, The stress values and deflection are found to be less when it is compared with the existing landing gear model. Here in this work the modified landing gear geometry has been found with less stress values and deflection during landing and takeoff which enhances the reliability and durability of the landing gear.

I. INTRODUCTION

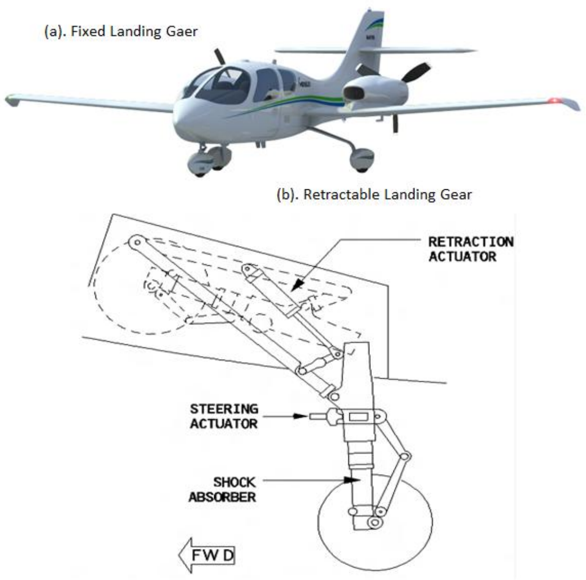
The Landing gear is a mechanical basis of structure which support aircraft on ground with all loads being transferred to the ground, even the main purpose of the landing gear is to support taxing, takeoff and also landing. It is the most important structural component which is takes the maximum possible load during takeoff and landing due to impact on ground. The landing gear as it's known for the support an aircraft on the ground which takes not only the loads from landing and takeoff systems but it also transfers the load by rate of compression and expansion to the adjoining structure like bulkheads, ribs and frames etc and prevents the damage to the landing gear structure.

1.1 Function and design requirements:
The aircraft keeps the stable on ground during landing. Loading and taxing. It helps the free movement and maneuver during taxing. Provides the ground clearance to aircraft parts. Absorbs sudden shock loads and hence protects aircraft from being damaged. and its functions is Ground clearance and Steering control, Rotation control requirement during take-off. Tip backward movement prevention requirement. aircraft landing control functions. aircraft structural strength and integrity, ground lateral stability and control, Economical cost with respect to weight to strength, Machinability, maintenance and manufacturability. For landing gear design Strength to weight ratio of landing gear, aircraft structural strength and integrity, feasible landing gear material for all operating environment, Economical cost with respect to weight to strength and production. Fixed and retractable landing gear after takeoff landing gear increases drag as the speed and landing gear size increases and performance of the aircraft decreases in FAR25 transport aircraft category so the thing is to decrease the drag on aircraft for transport category and during flight landing gears. Aircraft structural strength and integrity, Feasible landing gear material for all operating environment, So the work focuses on the loads which affects the functioning and strength of the landing gear considering above mentioned loads and are responsible design life.



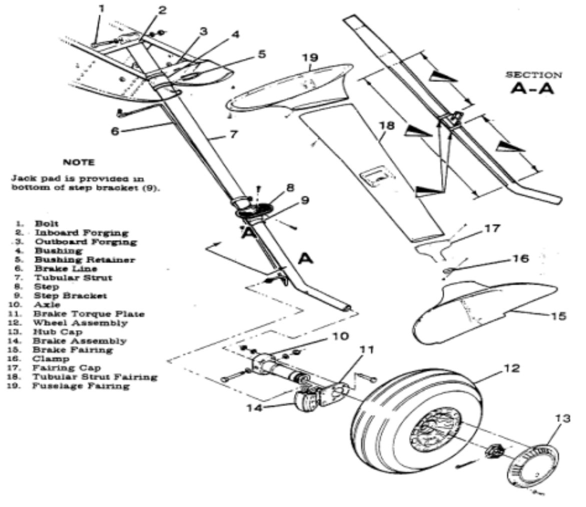
1.2. Landing gear configuration.
A Generally the configurations of landing gears are as follows:

- Single main landing gear
- Bicycle landing gear
- Tricycle or nose-gear
- Multi-bogey



1.2.1. Parts of Landing gear

Main landing gear parts



II. LOADS ON LANDING GEAR

Dead weight of Aircraft while in taxing and standing. Landing/Take-off time weight on Landing gears. repetitive loads in maintenance services. Thermal Stress and corrosion effects in environment. The loads on the aircraft decide the life of the aircraft landing gear based on the type of the material. So the work focuses on the loads which affects the functioning and strength of the landing gear considering above mentioned loads and are responsible design life.

III. METHODOLOGY

Several modified landing gear geometries are selected which are having same standard size in the light jet category. All the selected designs of the landing gear are modelled using commercially available CAD software CATIA V5 R16. All the landing gear CAD models are discredited by using ANSYS Workbench. the static structure analysis has done using ANSYS Mechanical. All the boundary conditions and the loads have been referred to literature. Structural analysis has been carried out for different landing gear configurations. The results obtained are validated with the literature and design of landing gear. The effects of stress concentration and deflection are achieved compared with the original landing gear configurations.

3.1 Analytical calculation for the deflection of landing gear strut.

The Landing gear strut deflection or the aircraft shock absorber system depends on touchdown velocity fatigue and fracture loads on the Landing gears. Landing, takeoff. The impact energy is absorbed by deformation of strut and same is converted kinetic energy into deflection.

The kinetic energy absorbed in the strut:

$$\Delta K.E = 0.5 * W * V_{n1}^2 \qquad (1)$$

Where

W =Gross weight of an aircraft.

V_{n1}^2= Vertical velocity of the airplane at touchdown (m/s).

from the sink speed the total kinetic energy absorbed by landing gear can be found.

$$E_{absorb} = w * g * N_g(\eta_t . S_t + \eta_s . S_s) \qquad (2)$$

Where: N_g: Gear load factor, S_t= stroke length for tire.

S_s= stroke length of landing gear strut , η_t =Efficiency of the tire

η_s = Efficiency landing gear strut

Equations. (1) And (2), yield Equation, (4)

$$0.5 * W * V_{n1}^2 = w * g * N_g(\eta_t . S_t + \eta_s . S_s) \qquad (3)$$

$$S_s = \frac{V_{n1}^2}{2g*(N_g*\eta_s)} - \frac{\eta_t}{\eta_s} * S_t \qquad (4)$$

$$= \frac{(2.38)^2}{2*9.81(2.5*0.5)}$$

$$S_s = 0.2309 \text{ m}$$

From the above calculation neglecting the tire system and sink speed of 7ft/sec and standard weight of the aircraft being 757kg [8] the stroke length is found to be 0.2309m

The acceleration at touchdown speed can be calculated from equation (5),

$$V_n^2 = V_o{}^2 + 2.a.S_s \qquad (5)$$

$$a = \frac{V_n^2 - V_0^2}{2 * S_s}$$

$$= \frac{1.2^2 - 2.38^2}{2 * 0.23}$$

$$a = 9.217\, m/s^2.$$

The yield value of acceleration is 9.217 m/s^2.

3.2 Analytical Load calculation.

The dynamic loads during landing on each gear from FAR23,is 2g as mentioned earlier by using the Newton second law,

$$F_n = \frac{W}{2} * a \qquad (6)$$

Total mass on the landing gear strut is 2g at landing therefore

$$F_n = W * a \qquad (7)$$

$$= 757 * 9.217$$

$$F_n = 6977 \text{ N}$$

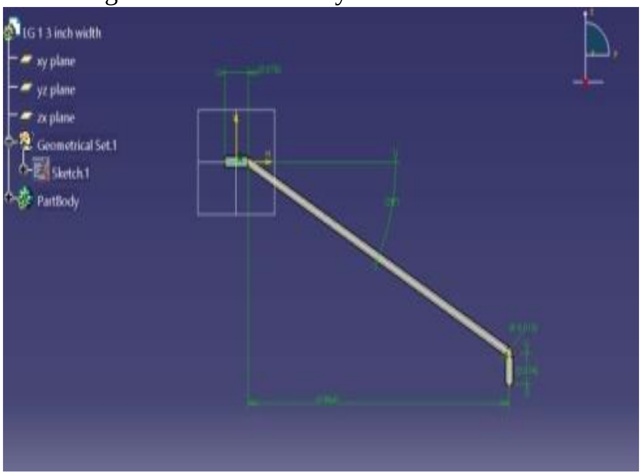
So from equation (7) normal force found to be 6977N.

As mentioned in the previous chapter the spin up or spring back force is half of the normal vertical force at touch down before the rotation of the wheel. So the spin up force is given by

$$F_{back} = 0.5 * F_n \quad (8)$$
$$= 0.5 * 6977$$
$$F_{back} = 3489 \text{ N}$$

From equation (6) the normal force will lead to 6977N, and equation (8) gives the value of spin up or spring back force is 3489N.

3.3 Landing Gear Strut Geometry Model



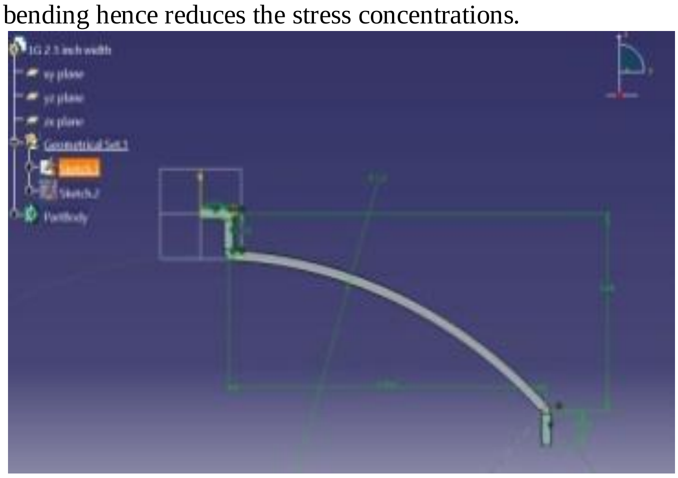
Baseline Landing gear strut

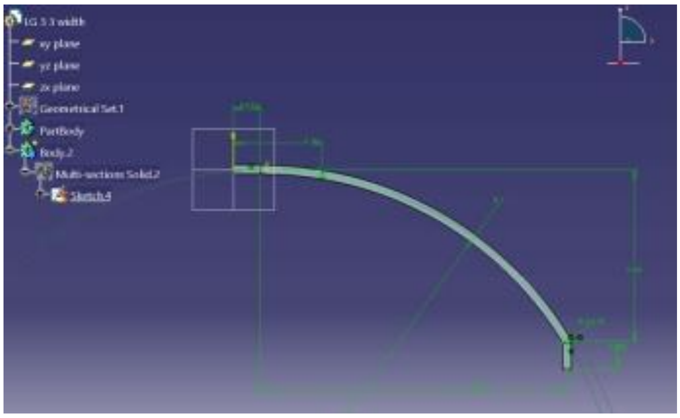
The basic dimensions of the landing gear are referred with respect to Cessna 152 aircraft data sheet. The aircraft is employed with fixed tricycle landing gear Baseline landing gear geometric parameters.

S.N	Parameter	Dimensions
1	Length	952mm
2	Height	548mm
3	Width	76mm
4	Thickness	33mm
4	Material	Steel 98S
5	Mass(in kg)	13 kg

Modified landing gear strut model 1 & 2

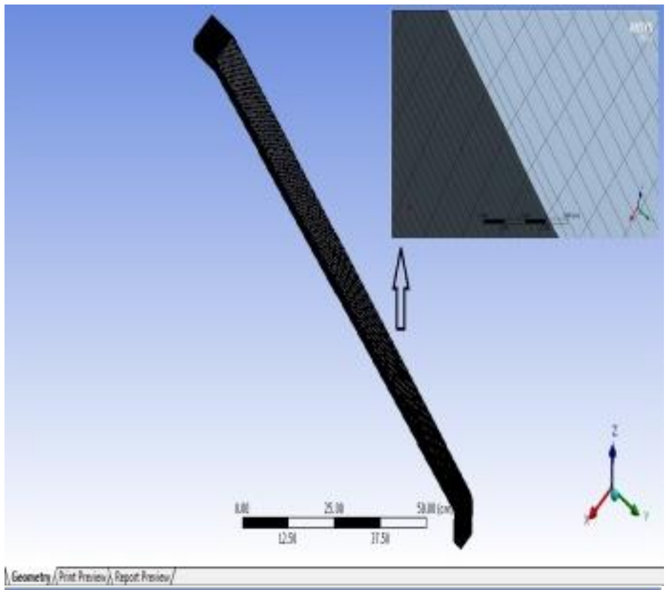
This model is choice between the base line and modified model one where the concept of curvature has been done here also the inclined shape of the geometry has been modified to convex shape which intern increases the stiffness to the bending hence reduces the stress concentrations.

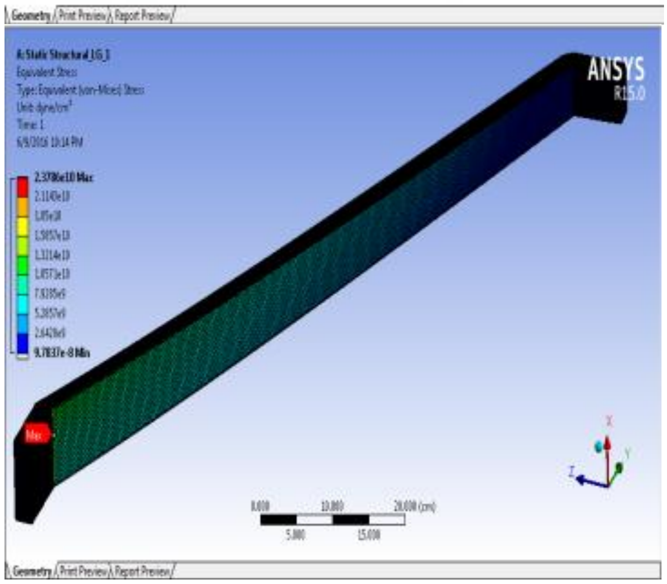




3.4 Meshed Model Details

A three dimensional Landing gear CAD model has been imported from CATIA V-5 R-20. The discretization of CAD model has been done using ANSYS Workbench meshing.The details of the mesh has been tabulated in the below shown table.





The quality of the mesh is often an issue which has to be taken into consideration in Finite element analysis and its consequences greatly influence the results. To understand the properties like stress,strain etc. The baseline landing gear has locally Discretization using sweep method to achieve the greater quality of Hexahedron mesh. Using edge sizing method the mesh has been more refined in the part expected stress concentration.

Mesh details		
S.N	Type	Details
1	Mesh type	Course default
2	Element size	Default
3	Hexahedron element	3D mesh
4	No. of Elements	265980
5	No.of Nods	1128863
6	Aspect ratio	3.06
7	Matrial	Steel 98S
8	Young's modulus	200Gpa
9	Poisson's ratio	0.3
10	Yield, tensile strength	850M Pa
11	Ultimate, tensile strength	1158 MPa

3.5 Discretization of CAD model 1 & 2
'Modified landing gear model -2 is exactly similar to the base line geometry model all the dimensions being same but the inclined geometry has been given convex shape that's curvature of the incline geometry has been increased to increase bending resistance and decrease stresses.

IV. RESULTS AND DISCUSSIONS

Here the static analysis has been carried out on all the models of landing gear and the requested results have been obtained for unknown parameters. Deformations, Stresses, Strains, stress, concentrations, Factor of safety. Boundary conditions and load applied model has been discretized as per the requirement and the loads have been applied. High strength steel material mechanical properties, high strength to weight ratio, the titanium alloy used as main landing gear material - Ti-5Al-5V-5Mo-3Cr,

4.1 THEORETICAL VALIDATION

The maximum stress in the baseline landing gear analysis, the location where maximum stress is found is considered for analysis.
Stress acting on base line landing gear:

$$\text{Stress} = {}^{\text{load}}/_{\text{area}} = 2.87\text{E}9\ \text{N/m}^2$$

$$\text{Stress} = {}^{10456.8}/_{3.126\text{E}-6} = 3.3458\text{E}9\ \text{N/m}^2$$

$$\text{Stress} = {}^{10456.8}/_{4.3589\text{E}-6} = 2.466\text{E}9\ \text{N/m}^2$$

for model-1& 2
From the above result we can say that the analysis value almost equal to the theoretical value obtained from Kt equation. Hence the analysis is considered as valid process. The static structural analysis has been done and analyzed all the three models for stress and deflections in the landing gear. From the static structural analysis of all models when compared with results, modified landing gear can take more fatigue cycles than the existing model. So the analysis concludes that the suggested models can be implemented for the Cessna trainer aircraft.
In the current project work we came to know concludes that the suggested models can be implemented for the same to Cessna trainer aircraft as on decreasing the stress and deflection by changing the following process.
1. There is possibility to change the model by varying parameter shape and size
2. We can change the material for future model by increasing the mesh density.
3. There is an implement for other methods to reducing shape of landing gear by keeping the same model
4. Depends on the stress value reduce, the lower material properties can be changed by material using, So that cost of the landing gear can be reduce

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