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Nutakki Priyatham, 2021, 9:5
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

Modelling and structural analysis of aircraft landing gear

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Abstract- The main objective of this paper is to present the model of the landing gear using Computer-aided design software in order to carry out structural analysis of the landing gear. Computer-aided design (CAD) and finite element analysis will be done to analyze the development of stress while landing. It also has the displacement analysis of the landing gear. For modelling of the landing gear SOLID EDGE ST9 software is used and for the analysis of the landing gear ANSYS 2021 R1 software is used.

Keywords: Modelling, stress analysis, total deformation, landing gear.

I. INTRODUCTION

Landing gear is a vital subsystem of the aircraft. The landing gear supports the aircraft when it's not flying. The main purpose of a landing system is to decrease impact loads by absorbing them while landing. It also must offer suspension, wheel steering and braking while the aircraft is taxiing on the airstrip. The design of this undercarriage is one of the fundamental aspects in design of aircraft. At the time of landing, the landing gear is subjected to repeated stresses due to thrust on upper part. Due to repetitive stresses, landing gear may fail. The failure of landing gear at the time of landing can have adverse effects on the aircraft. Therefore, the landing gear must be able to resist the impact of landing.

II. PRINCIPLES OF FLIGHT

Lift, drag, weight and thrust are the basic forces acting on the aircraft. Lift and drag are treated as aerodynamic forces because their existence isbecause of the movement of aircraft in the air. Lift is generated by air flow over the wing. Opposing the lift, weight pulls down the plane. The propeller or engine generates the thrust, and opposing drag is caused by air resistance on frontal area of the plane [1]. At the time of take-off, thrust must overcome drag and lift must overcome the weight of plane. In level flight at constant speed, thrust is equal to drag and lift is equal to the gravity. At the time of landing, thrust must be less drag and lift less than weight.

III. LANDING GEAR SELECTION

The selection of landing gear depends on the various factors. Even the design and position of landing gear are determined by different characteristics of each aircraft. Those characteristics can be geometry, weight, and mission requirements. The important features like size of tyres and number of tyres, number of bogies, brakes, and shock absorption mechanism, must be selected according to the industry and federal standards. This has to be done way before the design of aircraft progresses, because after that phase, it is very difficult and costly to change the design.

1. Design configurations:

In landing gear design process, the main task of an aircraft designer is to select the landing gear configuration. The design requirements are parts of design of aircraft which includes cost, aircraft stability, control, performance, consideration of operations, and ability of product.

In general, there are some landing gear configurations as follows:

- Conventional landing gear,
- Tricycle landing gear,
- Bicycle landing gear,
- Quadricycle landing gear.

2. Configuration selection:

The conventional tricycle landing gear is the most preferred configuration for commercial and cargo aircrafts. It provides almost level fuselage, cabin floor when the aircraft is on the ground. It provides improved stability at the time of breaking and ground manoeuvres. The conventional tricycle landing gear offers better view of runway while taxiing and take-off.

The tricycle gear features a single wheel within the front, and two or more wheels somewhat behind the aircraft's centre of gravity. Tricycle gear aircraft are the easiest for take-off, landing and taxiing. This landing gear configuration is the most widely used on aircraft.

3. Factors considered for design of landing gear:

- Landing gear weight,
- Compatibility in aerodrome,
- Centre of gravity of aircraft,
- Aircraft integration,
- Maximum strength of components.

4. Landing gear position:

The position of the landing gear depends basically on the considerations of stability during taxiing, take-off and landing.

5. Ground handling characteristics:

Airfield compatibility is one of the main considerations in landing gear design. Especially, the aircraft must be able to do the manoeuvres within the pre-planned space as it moves between the runway and passenger terminal. In the case of larger aircrafts, this factor will affect the dimensions of the wheelbase and the track.

6. Design of shock absorber:

The primary function of the shock absorber is to absorb the impact kinetic energy and dissipate the kinetic energy in order to reduce the effect on the airframe of aircraft. The shock absorbers may be an independent element or integrated with the landing gear strut. Shock absorbers are classified based on the type of spring used. Oleo-pneumatic shock absorbersare generally used in commercial aircrafts.

According to the analysis procedure as outlined, necessary algorithms were developed.The stroke and piston length are determined to meet design requirements.

IV. MODELLING OF LANDING GEAR

1. CAD Software for design of Landing gear:

1. Solid Edge ST9 Part – For 3D Component design.
2. Solid Edge ST9 Assembly – For assembling components of landing gear.

Solid Edge is a 3D CAD, parametric feature, and synchronous technology solid modelling software [2]. It offers functionalities like solid modelling, assembly modelling for mechanical designers. The version used for modelling here is ST9 released in 2016.

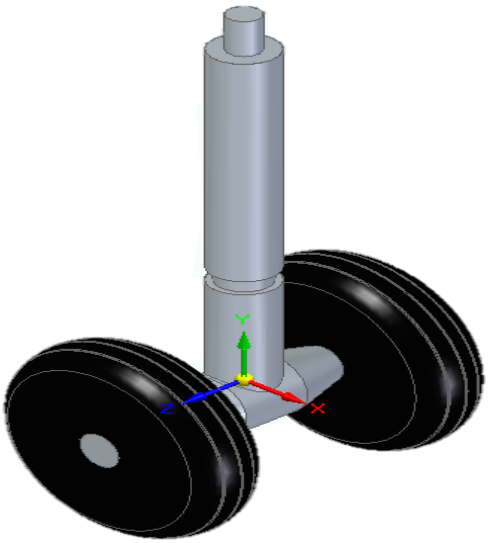

Fig1.Model of landing gear

V. FINITE ELEMENT ANALYSIS

The simulation process of a part or an assembly under given conditions in order to assess using finite element method is called finite element analysis [3]. This is used by engineers to replicate the physical conditions which reduces the need of physical components, thereby reducing the cost.

International Journal of Science, Engineering and Technology

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In this method of analysis, a complex part or shape is defined into simple shapes of geometry, which are called finite elements. Over these elements, the governing relationships and material properties are considered. The approximate behaviour of the part or assembly is obtained from the solutions of these equations.

1. Ansys:

Ansys is a CAE (Computer-aided Engineering) tool that allows to simulate the real behaviour of a model. It also helps to understand and improve the mechanical properties and performance of the design. Stresses, frequencies, deflections, heat transfer paths, and other factors can be calculated. Ansys shows how the model behave in the real world.It includes various modules like structural, thermal analysis, where structural mainly focuses on the structural integrity of the model, and thermal focuses on heat transfer characteristics.

The most common application of the finite element analysis is structural analysis. The term structure not only implies for civil engineering structures like buildings or bridges, but also implies for aerospace, mechanical, and naval as well. The aerospace structures include aircraft bodies, machine housings. The mechanical structures include pistons, machine tools and parts.

2. Meshing:

In the process of meshing, the geometric shape of an object is broken down into numerous small shapes to properly define the physical shape of the object. A detailed mesh leads to an accurate 3D CAD model with high fidelity simulations. Meshing generates a 2D and 3D grid which divides complex geometries into smaller elements which is used to discretize a whole domain [4]. Figure 2 shows the meshing done in Ansys Workbench.

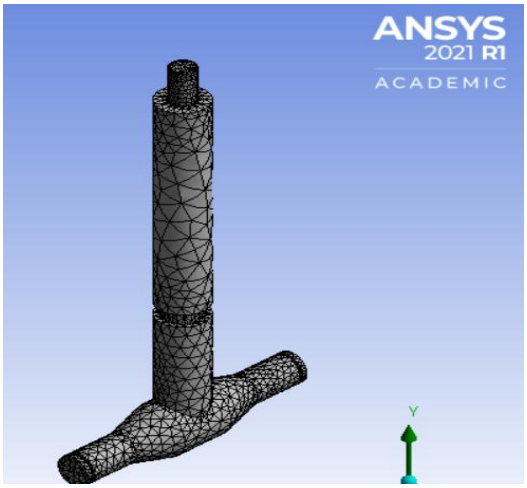

Fig 2. Meshing

3. Process:

The material considered for the analysis is Titanium alloy, as it is widely used in landing gear [5]. The upper part of the oleo is fixed, and force is applied on the axle of the landing gear in y-direction. Figure 3 shows the part on which the pressure(A) is applied and the part which is considered as fixed support(B) for analysis.

Pressure applied on axle: 1.0e+006Pa

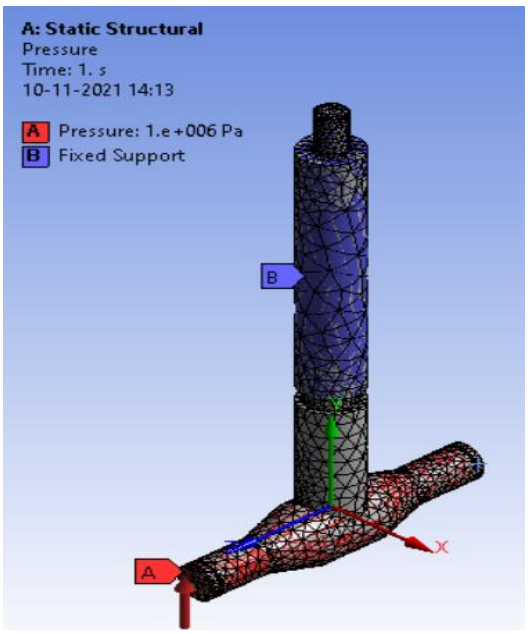

Fig 3. Analysis considerations

VI. CONCLUSION

Landing gear design is one of the prominent aspects in the design of aircraft. At the time of landing, the aircraft is subjected to repeated stresses. Due to the repetitive stresses, landing gear may fracture below yield point stresses.

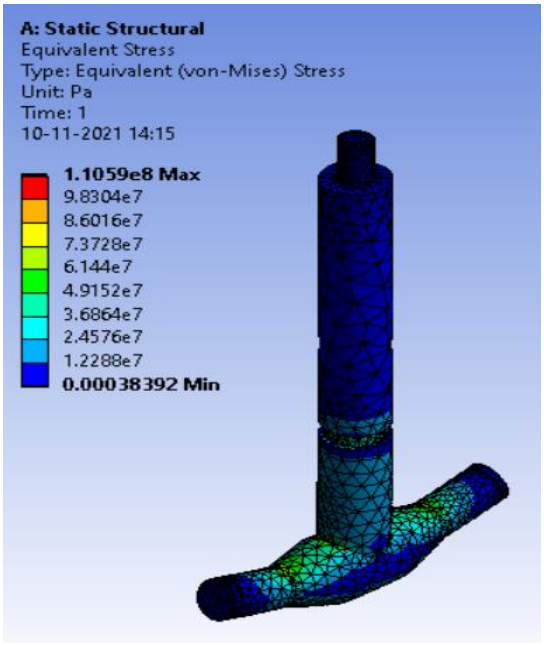

Fig 4. Displacement analysis

The failure of landing gear can have catastrophic effects on the aircraft. Therefore, the landing gear has to overcome the impacts of landing. So, in this project prototype of landing gear is designed and maximum stress and maximum displacement is calculated. Figure 4 shows the total deformation of landing gear, where the colours show the amount of deformation. Figure 5 shows the stress analysis on the landing gear. The lower part of oleo experiences more stress. Table 1 shows the result of the analysis.

Table 1. Results

Type	Equivalent Stress (Pa)	Total Deformation (m)
Minimum	3.8392e-004	0
Maximum	1.1059e+008	1.0784e-003
Average	1.4182e+007	3.0122e-004

- The maximum equivalent stress is 1.1059e+008 Pa which is less than yield strength 9.3e+008 Pa. So, the design is safe under given working condition.
- The maximum displacement is 1.0784e-003 m.

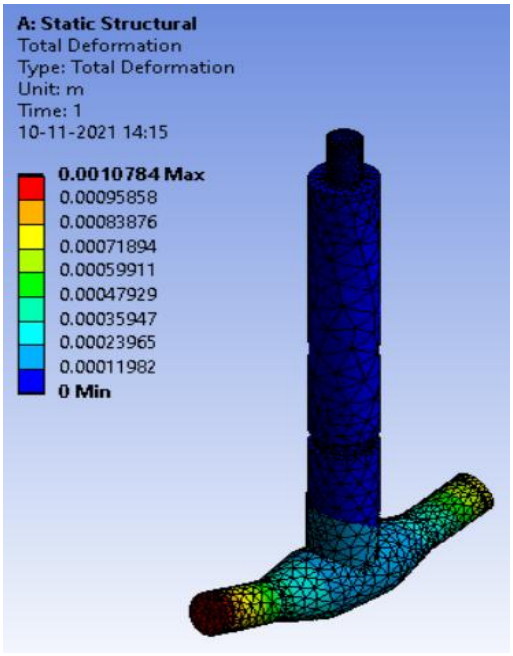

Fig 5. Stress analysis

REFERENCES

[1] A.C. Kermode, "Mechanics of Flight", Sir Isaac Pitman & Sons Ltd., London.

[2] Sham Tickoo, "Solid Edge ST9 for designers, 14th Edition", CADCIM Technologies, 2017.

[3] Ashok D Belgundu, Tirupati R Chandrupatla, "Introduction to Finite Elements in Engineering", Prentice Hall of India Private Limited, New Delhi, 2001.

[4] https://simutechgroup.com/why-is-meshing-important-for-fluid-simulations/

[5] Titterton G., Aircraft Materials and Processes, Pitman Publishing Co., 2004.