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LANDING GEAR OF AN AIRCRAFT- A REVIEW

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ABSTRACT

Landing gear is the undercarriage of an aircraft. Landing gear of an aircraft is an equipment that serves two primary functions. First, it allows aircraft to safely and successfully land and second is to support aircraft at rest condition. Landing gear is designed according to requirement and nature of work of aircraft. Landing gear of an aircraft is an equipment that serves two primary functions. First, it allows aircraft to safely and successfully land and second is to support aircraft at rest condition. Landing gear is designed according to requirement and nature of work of aircraft. In this project, we will first study all functional specifications and parts of landing gear which can affect purpose an aircraft. Some of these parts to be consider are:

1. Type (e.g. nose gear (tricycle), tail gear, bicycle)
2. Fixed (faired, or un-faired), or retractable, partially retractable
3. Height
4. Wheel base
5. Wheel trackThe distance between main gear and aircraft cg
6. Strut diameterTire sizing (diameter, width)
7. Landing gear compartment if retracted.

In this project work, we will optimize design of landing gear by considering different material properties, loading conditions and dimension optimization with different landing conditions during operation.

Keywords

Landing gear, skis, skids, impact load, steering ratio, anti skid break management system, maneuvering, shock strut, air worthiness regulation.

1. INTRODUCTION

Aircraft's major component that is needed to be designed is landing gear (undercarriage). The landing gear is the structure that supports an aircraft on the ground and allows it to taxi, take-off, and land. In fact, landing gear design tends to have several interferences with the aircraft structural design. In this book, the structural design aspects of landing gear are not addressed; but, those design parameters which strongly impact the aircraft configuration design and aircraft aerodynamics will be discussed. In addition, some aspects of landing gear such shock absorber, retraction mechanism and brakes are assumed as non-aeronautical issues and may be determined by a mechanical engineer. Thus, those pure mechanical parameters will not be considered in this chapter either. In general, the followings are the landing gear parameters which are to be determined in this chapter:

1. Type (e.g. nose gear (tricycle), tail gear, bicycle)
2. Fixed (faired, or un-faired), or retractable, partially retractable
3. Height
4. Wheel base
5. Wheel track
6. The distance between main gear and aircraft cg
7. Strut diameter
8. Tire sizing (diameter, width)
9. Landing gear compartment if retracted

The landing gear usually includes wheels, but some aircraft are equipped with skis for snow or float for water. In the case of a vertical take-off and landing aircraft such as a helicopter, wheels may be replaced with skids. Landing gear height is the distance between the lowest point of the landing gear (i.e. bottom of the tire) and the attachment point to the aircraft. Since, landing gear may be attached to the fuselage or to the wing; the term height has different meaning. Furthermore, the landing gear height is a function of shock absorber and the landing gear deflection. The height is usually measured when the aircraft is on the ground; it has maximum takeoff weight; and landing gear has the maximum deflection (i.e. lowest height). The need to design landing gear with minimum weight, minimum volume, reduced life cycle cost and short development cycle time, poses many challenges to landing gear designers and practitioners. These challenges have to be met by employing advanced technologies, materials, analysis method, processes and production methods. Various design and analysis tools have been developed over the years and new ones are still being developed.

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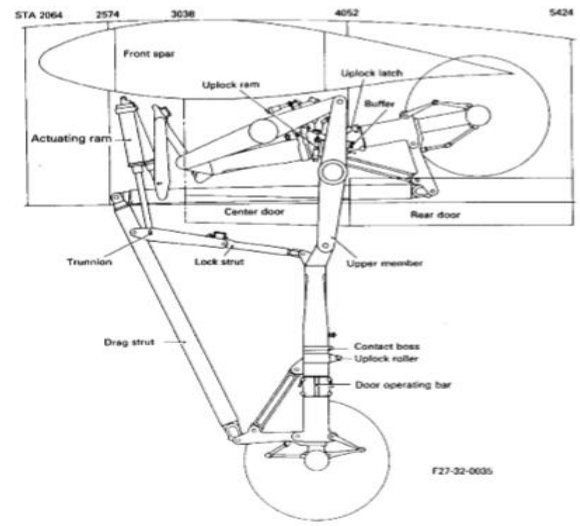

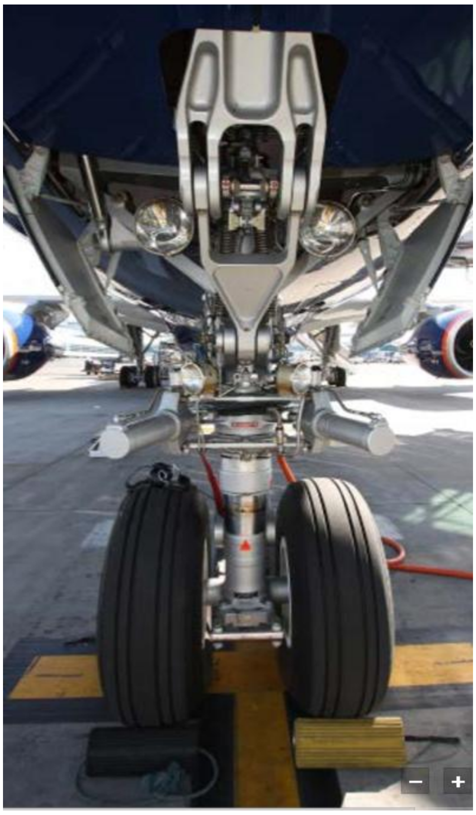

The purpose of the landing gear in an aircraft is to provide a suspension system during taxi, take-off and landing. It is designed to absorb and dissipate the kinetic energy of landing impact, thereby reducing the impact loads transmitted to the airframe. The landing gear also facilitates braking of the aircraft using a wheel braking system and provides directional control of the aircraft on ground using a wheel steering system. It is often made retractable to minimize the aerodynamic drag on the aircraft while flying. The landing gear should occupy minimum volume in order to reduce the stowage space requirement in the aircraft. Typical Main Landing Gear (MLG)and Nose Landing Gear (NLG)are shown in figure 1. The nose gear will have additional elements like steering actuator and steering mechanism.

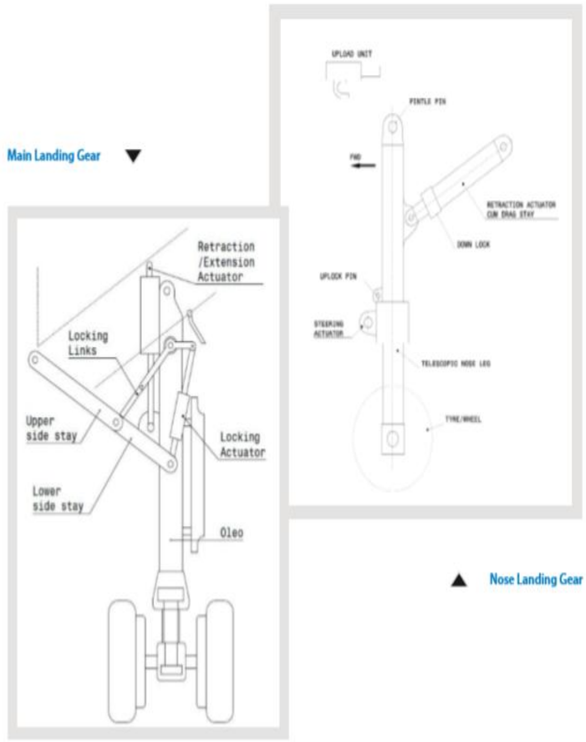

Figure 1 Aircraft Landing Gears

2. AN OVERVIEW OF LANDING GEAR

2.1 Design and Development

The landing gear design and integration process encompasses knowledge of many engineering disciplines such as structures, dynamics, kinematics, fluid mechanics and runway flotation. The geometry, flotation requirements of the aircraft govern the landing gear configuration. The configuration design includes choice of number of wheels, tire sizes, pressures, type of shock absorbers, landing gear layout, retraction kinematics and bay geometry design.

Airworthiness regulations play a crucial role in arriving at the landing gear configuration, such as sink rate, allowable load factors and ground maneuvering conditions, stipulated in the applicable airworthiness regulations

Some of these Airworthiness Regulations are given in Table 1.

Aircraft Type	Regulations/ Specifications
Utility and Aerobatic Airplanes	FAR 23, CS 23, CAR 23
Civil Transport Airplanes	FAR 25, CS 25, CAR 25
Military Aircraft	US MIL Specifications, DEF-STAN-970

Table 1: Airworthiness Regulations

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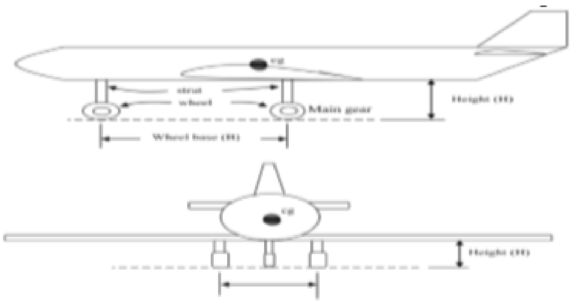
Landing gear torque arm position analysis and the optimization design[3]

The influence of the torque arm position of shock-strut landing gear on the potential seizure phenomenon of the shock absorber is analyzed, and the general calculation formula of reaction force of the piston rod for forward stretching and lateral stretching landing gear is also derived in the paper. Based on above research, the optimization design method of the torque arm position is put forward, which solving the torque arm position to make the piston rod counterforce minimum. Namely, for the optimal design method, the target function is piston rod counterforce, and the design variable is the position of torque arm in relation to the strut of landing gear. Finally, a set of computer programs of the optimal design method are compiled, which has been proved that is totally applicable for the inside or outside wheel of strut and forward or lateral stretching shock-strut gear.



CAD modeling by using CREO-ELEMENT/PRO 5.0 Software

Assembly is the process in which two or more objects are joined together to achieve the desired function. Assembly modeling is the process of creating designs that consist of two or more components assembled together at their respective work positions. The components are brought together and assembled in the Assembly Design environment by applying suitable parametric assembly constraints to them. The assembly constraints allow restricting the degrees of freedom of the components at their respective work positions.

2.2 Concept Design

Te concept design starts with a study of all design specifications and airworthiness regulations. A concept is then evolved while meeting the functional and regulatory requirements. Major design drivers are performance, safety, cost, time frame, technology and resources. The landing gear location is arrived at and type of landing gear geometry is defined along with kinematics. Steering concepts are also identified in this phase. The ground loads are estimated using dynamic simulations for material selection and preliminary sizing of components. The actuation mechanisms and loads are also worked out in this phase. Various tradeoff studies are performed to optimize weight, volume and cost. Based on these trade-off studies a best concept is selected.

2.3 Preliminary Design

In the preliminary design phase, dynamic simulations are carried out for landing, take off and retraction kinematics to arrive at data required for sizing of components and material selection. Preliminary design of components is performed and weight estimates are arrived at.

2.4 Detailed Design

In this phase the detailed design of all the landing gear components is performed and an integrated landing gear system is defined with all interfaces and associated systems. Components loads are estimated and material selection and sizing are done in this phase. Reduction is part count by making closed die forgings for complex shapes is done through 3D CAD modeling. Dynamic analysis and simulation is carried out to fine tune certain design parameters for energy absorption, shimmy suppression and retraction/extension. In this phase digit mock-up of the landing gear is developed which is essentially the virtual prototype of the landing gear. All lesions learned and best practices evolved over the years are utilized in the detail design to realize a reliable design.

2.5 Landing Gear Technologies

Landing gear technologies are continuously evolving to meet the challenges of functional and non-functional requirements. Some of these important technologies are presented below:

2.5.1 Steering System

Steering control system are moving towards electronic contro systems replacing hydro-mechanical systems. The control system as its accuracy and its ability to incorporate changes in design parameters like steering rate and steering ratio with ease.

2.5.2 Actuation System

In actuation systems, more electric or all electric systems are replacing the conventional hydraulic systems. The electric systems offered today have become weight competitive with use of brushless high systems helps to overcome problems of leakage and fire hazard

2.5.3 Brake System

Electronically controlled antiskid brake management systems are replacing old mechanical or electric antiskid systems. Electronic systems are more efficient and trouble free.

2.5.4 Tires

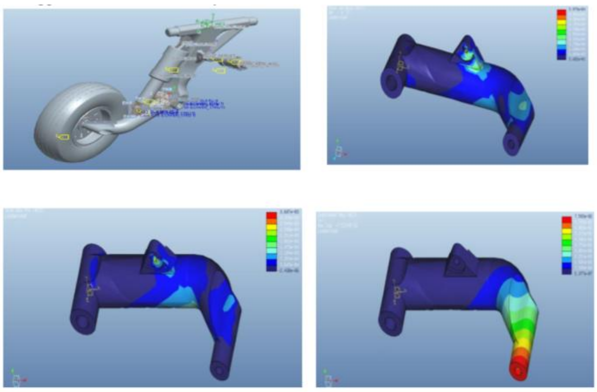
Radial tire is one of the advanced technologies employed in aircraft for the past 25 years. Landing gear radial tires offer lighter tires with longer life compared to blas ply tires

3. ASSEMBLY-DESIGN APPROACHES

Analyze assembly from the finished assembly and work down. So, begin with the master assembly and break it down into assemblies and subassemblies. Then, identify the main assembly components and their key features. Finally, understand the relationships within and between assemblies, and assess how the assembly will be assembled. With this information, I can plan a design and leverage overall design intent into our models. Top down design is the industry paradigm for companies that design assemblies that undergo frequent design modifications or for those companies that design diverse assemblies. Adopting the top-down design approach gives the user the distinctive advantage of using the geometry of one component to define the geometry of the other component. Here, their construction and assembly take place simultaneously. As a result, the user can view the development of the assembly in real time. This design approach is highly preferred while working on a conceptual design or a tool design where a reference of the previously created parts is required to develop a new part.

4. ANALYSIS BY USING ANSYS 11.0 SOFTWARE

Structural analysis is probably the most common application of the finite element method. The term structural (or structure) implies not only civil engineering structures such as bridges and buildings, but also naval, aeronautical, and mechanical structures such as ship hulls, aircraft bodies, and machine housings, as well as mechanical components such as pistons, machine parts, and tools. Structural Analysis is a multi-discipline Computer Aided Engineering (CAE) tool that analyzes the physical behavior of a model to better understand and improve the mechanical performance of a design. It can be used to directly calculate stresses, deflections, thus to predict the behavior of the design in the real world. Structural Analysis is available in the integrated mode of Pro/E and analysis can be performed within the Pro/E environment. Pro/E Structural Analysis and Pro/E Thermal Analysis share a very similar approach. Most of the procedures presented in this tutorial, such as model creation, constraints definition and load specification, are also applicable to Thermal Analysis.



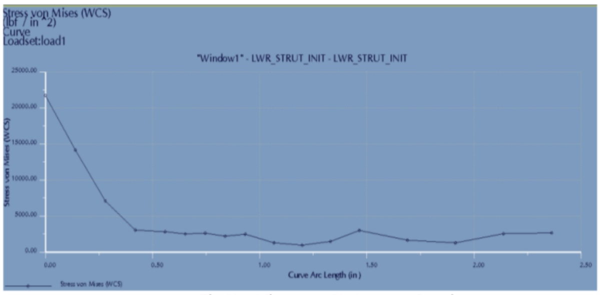


Fig: Von Mises Stress Vs Curve Arc Length

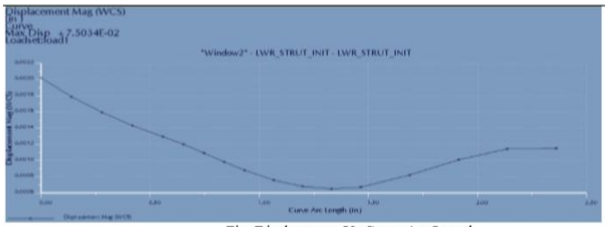


Fig: Displacement Vs Curve Arc Length

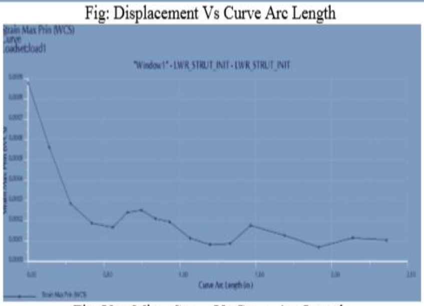
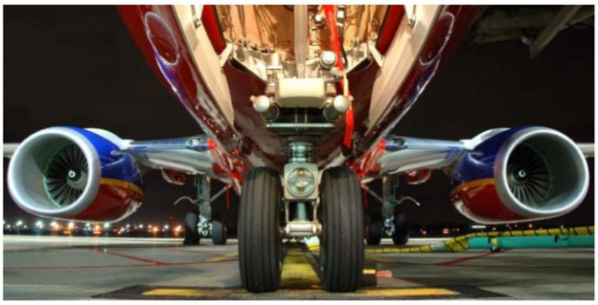


Fig: Von Mises Stress Vs Curve Arc Length

5. CONCLUSION

From above work, it has been clear that the landing gear can be design and modeled using PRO-E as per requirements. We can perform integrated simulation on a Pro/E assembly and automatically meshed model can be generated containing very small sections. From above analysis, one can get early insight as to its performance and can analyze a concept model to automatically obtain accurate stresses and displacements. On this basis one can optimize the design by changing relevant parameters and material. In this way, one can design a landing gear for a greater performance to suit for the purpose. The need to design landing gear with minimum weight , minimum volume, high performance, improved life and reduced life cycle cost have posted many challenges to landing gear designers and practitioners. The future landing gear design for aircraft poses many new challenges in configuration design, use of materials, design and analysis methods.



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