“LANDING GEAR”

Submitted in partial fulfilment of the requirements for the award of the

BACHELOR OF SCIENCE

IN

AERONAUTICS (AVIONICS)

BY

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BONAFIDE CERTIFICATE

This is to certify that the project report titled “LANDING GEAR” is a bonafide record of work carried out by “Ms. BHOSALE APARNA NAMDEO” during the final semester from “Nov 2019” to “May 2020” under my guidance, in partial fulfilment of the **requirements for the award of BACHLOR OF SCIENCE- in AERONAUTICS** (AVIONICS)

Prof. Dr. M Suresh Kumar
Principal

DECLARATION

I, Bhosale Aparna Namdeo hereby declared that this project report titled "Landing Gear" submitted in partial fulfilment of the requirement **for the Award of "BACHLOR OF SCIENCE- in AERONAUTICS** (AVIONICS)**" is my original work and it has not formed the basis for the award of any other degree.**

Bhosale Aparna Namdeo

Place:

Date:

TABLE OF CONTENT

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Student Name: Bhosale Aparna Namdeo

ABSTRACT

Landing gear is one of the critical subsystems of an aircraft. The need to design landing gear with minimum weight, minimum volume, high performance, improved life, and reduced life cycle cost have posed many challenges to landing gear designers and practitioners. Further, it is essential to reduce landing gear design and development cycle time while meeting all the regulator and safety requirements. Many technologies have been developed over the years to meet these challenges in design and development of landing gear. This paper presents a perspective on various stages of landing gear design and development, current technology landscape and how these technologies are helping us to meet the challenges involved in the development of landing gear and how they are going to evolve in future.

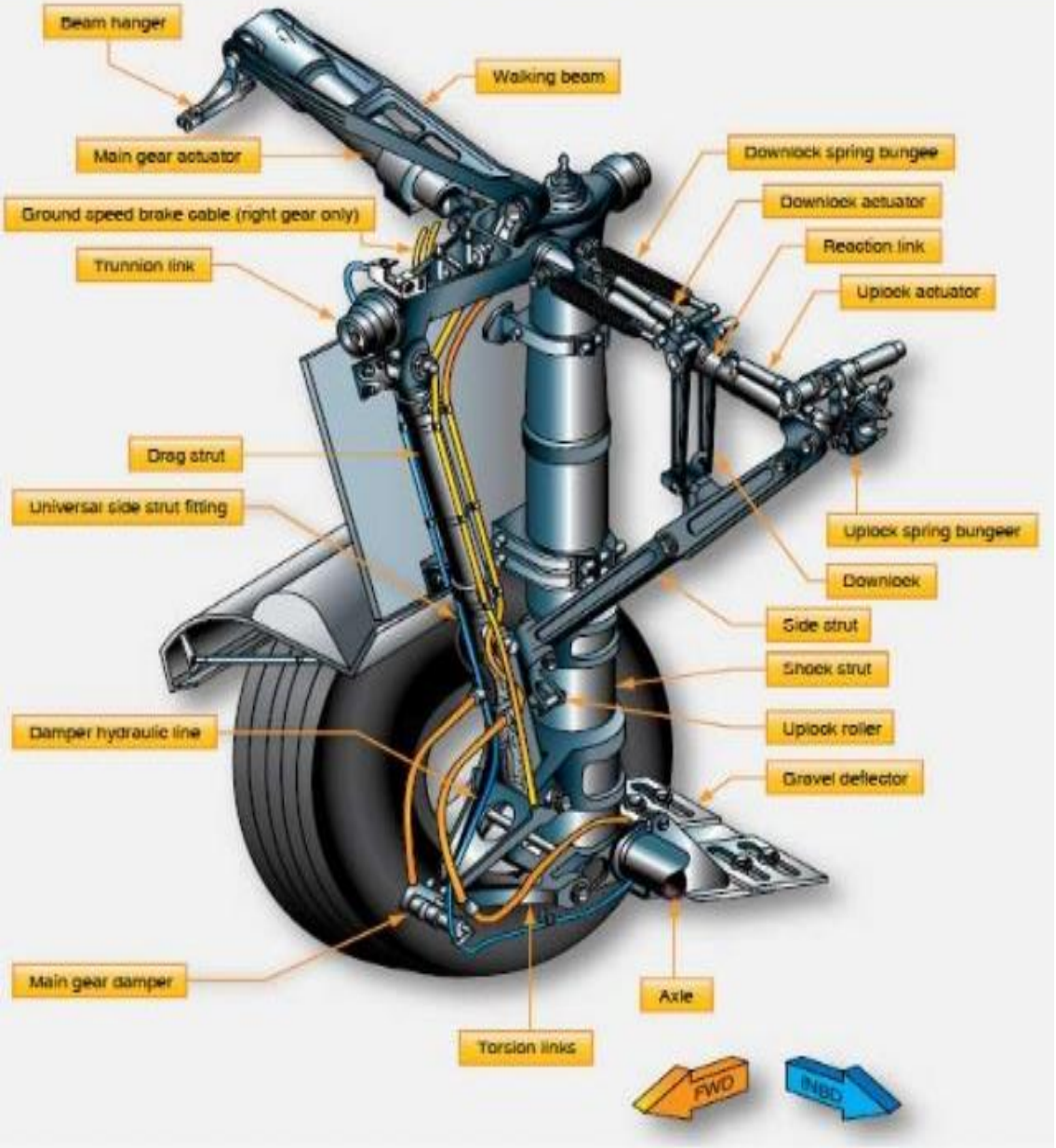
INTRODUCTION

Landing gear system is one of the critical and important systems of an aircraft and is often configured along with the aircraft structure because of its substantial influence on aircraft structural configuration itself. Landing gear detail design is taken up early in the aircraft design cycle due to its long product development cycle time. The need to design landing gear with minimum weight ,volume, reduced life cycle cost, and short development cycle time, poses many challenges to landing gear designers an practitioners. These challenges have to be met by employing advanced technologies, materials, analysis methods, processes and production methods. Various design and analysis tools have been developed over the years and new ones are still being developed.

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 design takes into account various requirements of strength, stability, stiffness, ground clearness, control and damping under all possible ground attitudes of the aircraft. These requirements are stipulated by the airworthiness regulation to meet operational requirements and safety. The landing gear should occupy minimum volume in order to reduce the stowage space requirement in the aircraft. Further, weight should be at minimum to increase the performance of the aircraft. The service life of the landing gear should be as same as the aircraft.

CONSTRUCTION



OBJECTIVE

The aim of this project is to design, model and test a landing gear for planes. It is important in maintaining its structural integrity allows planes to land smoothly as well as take-off efficiently. The main purpose of the landing gear in an aircraft is to provide suspension system during taxi, take-off and landing. It is designed to absorb and dissipate the kinetic energy of landing impact loads transmitted to the airframe.

THEORY OF PROJECT

LANDING GEAR

Landing gears are designed to support the aircraft while grounded and to withstand high loads during landing without any damage to its structure while providing comfort to passengers.

Landing gear is the undercarriage of an aircraft and for either take-off or landing. For aircraft it is generally used for both. Landing gear supports the aircraft when it is not flying, allowing it to take off, land and taxi without damage. Wheeled landing gear is the most common with skis or floats needed to operate from snow/ice/water and skids for vertical operation on land. Faster aircraft have retractable undercarriages, which fold away during flight to reduce drag.

The landing gear of fixed wing aircraft consist of main and auxiliary unit, either of which may or may not be retractable. The main landing gear forms the principal support of the aircraft on the land or water and may include any combination of wheels, floats, skids, shock- absorbing equipment, brakes, retracting mechanism with controls and warning devices, cowling, fairing, and structural members necessary to attach any of the foregoing to primary structure. The auxiliary landing gear consist of tail or nose wheel installations, outboard pontoons, skids, etc., with necessary cowling and reinforcement.

A landing gear system comprises of many structural and system components. The system components include Main fitting , shock absorber, bogie beam/Trailing arm, Axle, Torque links, Drag/side braces, Retraction actuator, Down lock mechanism. Up lock, Wheel, Tire etc. The system components are brake unit, Antiskid system, retraction system components.

As we know landing gear is designed to support the load of the aircraft for the surface operations. Several types exist, designed for the intended operation or desires performance. The landing gear typically consist of three wheels:

- Two main wheels (one located on each side of fuselage)
- A third wheel positioned either at the front or rear of the airplane.
    - When the third wheel is located on the tail, it is called a tail-wheel, and the design referred to as **conventional gear**.
    - When the third wheel is located on the nose, it is called a nose-wheel, and the design is referred to as a **tricycle gear**.
    - Aircraft can also be equipped with floats for water operations or skis for landing on snow.

TYPES OF LANDING GEAR

There are several types of landing gear which fall into main four categories:

- Conventional gear(tail-wheel)
- Tricycle gear
- Pontoons
- Ski-planes

Conventional Gear:

- Landing gear employing a rear-mounted wheel is called conventional or tail-wheel gear.
- Tail-wheel landing gear aircraft have two main wheels attached to the airframe ahead of its Centre of Gravity (CG) that support most of the weight of the structure.

Advantages:

1. Allows adequate ground clearance for a larger propeller.
2. More desirable for operations on unimproved fields.

Disadvantages:

1. With the CG located behind the main gear, directional control of this type aircraft becomes more difficult while on the ground,
   If the pilot allows the aircraft to swerve while rolling on the ground at a low speed, he or she may not have significant rudder control and the CG will attempt to get ahead of the main gear which may cause airplane to ground loop.
2. Lack of good forward visibility when the tail-wheel is on or near the ground.

Tricycle Gear:

- Landing gear employing a front-mounted wheel is called tricycle landing gear.
- Tricycle landing gear aircraft have two main wheels attached to the airframe behind its CG that supports most of the weight of the structure.
- Additionally, a nose wheel will typically provide some sort of nose wheel steering control.

Advantages:

1. It allows more forceful application of the brakes during landings at high speeds without causing the aircraft nose over.
2. It permits better forward visibility for the pilot during takeoff, landing and taxing.
3. It tends to prevent ground looping by providing more directional stability during ground operation since the aircraft CG is forward of the main wheel.
   The forward CG keeps the airplane moving forward in a straight line rather than ground looping.

Pontoons:

- One or more pontoons, or floats are mounted under the fuselage to provide buoyancy.
- By contrast, a flying boat such as the consolidated PBY Catalina, uses its fuselage for buoyancy.
- Either type of seaplane may also have landing gear suitable for land making the vehicle an amphibious aircraft.

LANDING GEAR DESIGN

Depending on an aircraft's intended operation landing gear may be designed as either:

- Fixed gear
- Retractable gear

FIXED GEAR:

- Fixed gear is designed to simplify design and operation.
- Many small, single-engine light aircraft have fixed landing gear, as do few light twins.
- This means the gear is attached to the airframe and remains exposed to the slipstream as the aircraft is flown.
- As the speed of aircraft increases, so does parasite drag. Mechanism to retract and stow the landing gear to eliminate parasite drag add weight to the aircraft.
- On a slow aircraft, the penalty of this added weight is not overcome by the reduction of drag, so fixed gear is used.
- As the speed of aircraft increases, the drag caused by landing gear becomes greater and a means to retract the gear to eliminate parasite drag is required, despite the weight of mechanism.
- A great deal of the parasite drag caused by light aircraft landing gear can be reduced by building gear as aerodynamically as possible and by adding fairing or wheel pants to streamline the airflow past the protruding assemblies.
- A small, smooth profile to the oncoming wind greatly reduces landing gear parasite drag.
- The thin cross section of the spring steel struts combine with the fairings over the wheel and brake assemblies to raise the performance of the fixed landing gear by keeping parasite drag to a minimum.

Advantages

- Always deployed
- Low cost

Disadvantages

- Creates constant drag, mitigated by the use of cover called firing.

RETRACTABLE LANDING GEAR:

- A retractable gear is designed to streamline the airplane by allowing the landing gear to be stowed inside the structure during cruising flight.
- The primary benefits of being able to retract the landing gear are increased climb performance and higher cruise airspeed due to the resulting decrease in drag.
- Retractable landing gear systems may be operated either hydraulically or electrically, or may employ a combination of the two systems.
- Warning indicators are provided in the cockpit to show the pilot when the wheels are down and locked and when they are up and locked or if they are in intermediate positions.
- Systems for emergency operation are also provided.

Disadvantages:

- Increased weight
- Increased cost
- Limited to high performance aircraft.

OPERATING RETRACTABLE LANDING GEAR

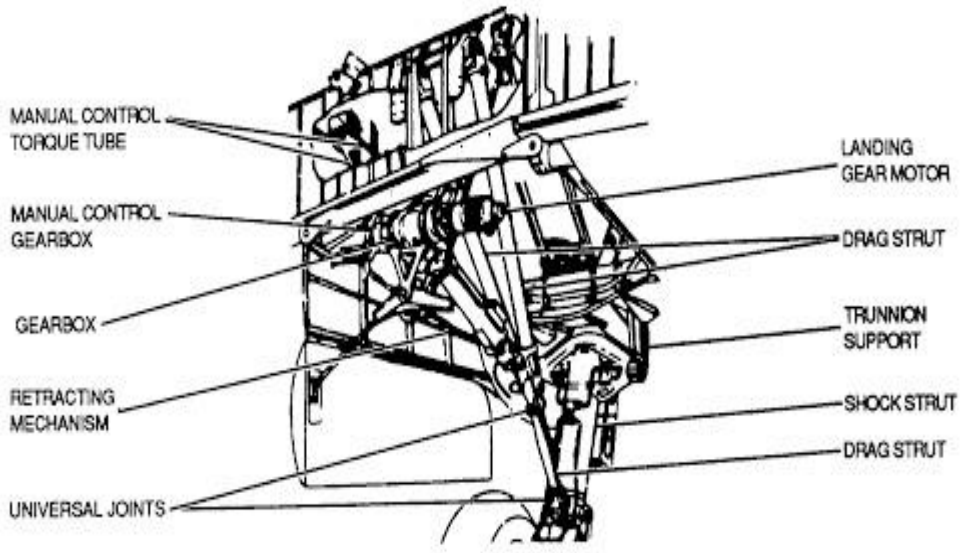
The landing gear, if retractable, may function with either electrical or hydraulic power.

ELECTRICAL:

An electrical landing gear retraction system has the following features:

1. A motor for converting electrical energy into rotary motion.
2. A gear reduction system for decreasing the speed and increasing the force of rotation.
3. Other gears for changing rotary motion (at a reduced speed) into push-pull movement.
4. Linkage for connecting pull-push movement to the landing gear shock struts.

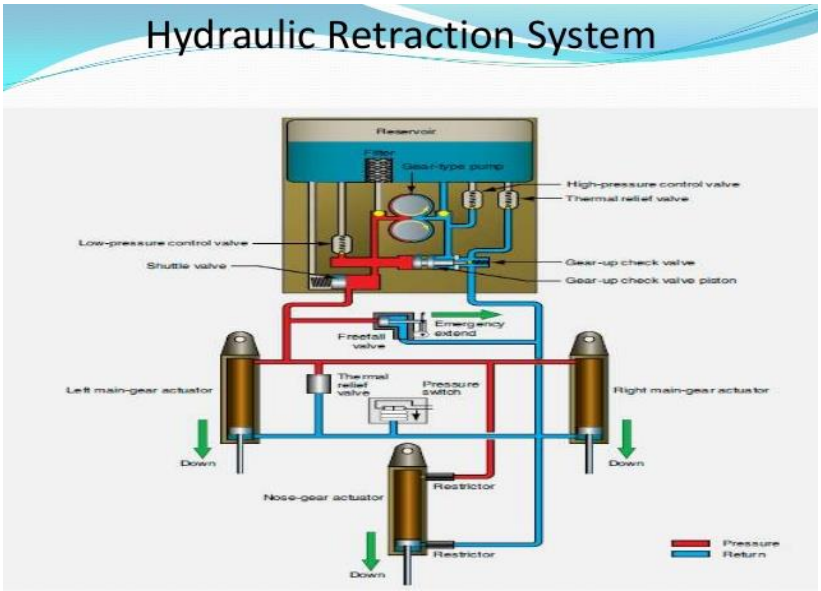
- An electrical landing gear retraction system utilizes an electrically driven motor for gear operation.
- When a switch in the cockpit is moved to UP position, the electric motor operates – through a system of shafts, gears, adapters, an actuator screw, and a torque tube, a force is transmitted to the drag strut linkages. The gear retracts and locks. The struts that open and close the gear doors are also activated.
- If the switch is moved to the DOWN position, the motor reverses and the gear moves down and locks.
- Once activated the gear motor will continue to operate until an up or down limit switch on the motor's gear box is tripped.

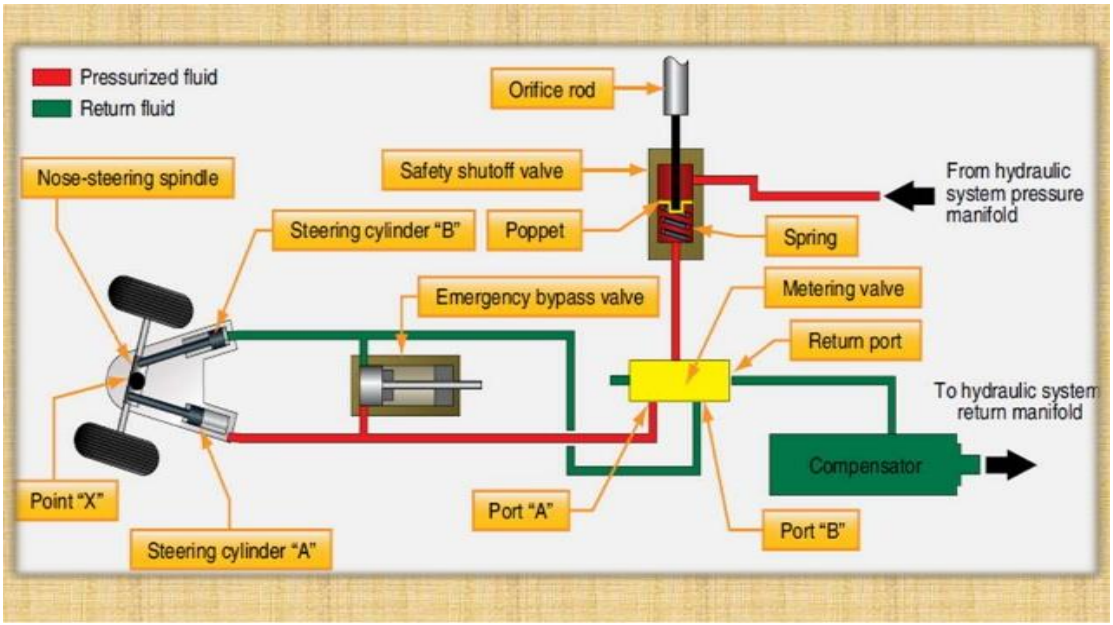


HYDRAULIC:

- A hydraulic landing gear retraction system utilizes pressurizes hydraulic fluid to actuate linkages to raise and lower the gear.
- When a switch in a cockpit is move to the UP position, hydraulic fluid is directed into the gear up line.
- The fluid flows through sequenced valves and down-locks to the gear actuating cylinders.
- A similar process occurs during gear extension.
- The pump which pressurizes the fluid in the system can be either engine driven or electrically powered.
- If an electrically powered pump is used to pressurize the fluid, the system is referred to as an electro-hydraulic system.
- The system also incorporates a hydraulic reservoir to contain excess fluid, and to provide a means of determining system fluid level.
- Regardless of its power source, the hydraulic pump is design to operate within a specific range.
- When a sensor detects excessive pressure, a relief valve within the pump opens, and the hydraulic pressure is routed back to the reservoir.
- Another type of relief valve prevents excessive pressure that may result from thermal expansion.

- Hydraulic pressure is also regulated by limit switches.
- Each gear has two limit switches-one dedicated to extension and one dedicated to retraction.
- These switches de-energize the hydraulic pump after the landing gear has completed its gear cycle.
- In the event of limit switch failure, a backup pressure relief valve activates to relieve excess system pressure.





LANDING GEAR SWITCHES AND INDICATORS

- Landing gear position is controlled by switch in a cockpit.
- In most airplanes, the gear switch is shaped like wheel in order to facilitate positive identification and to differentiate it from the other cockpit controls, such as the flaps.
- Landing gear position indicators vary with different make and model airplanes but the most common types of landing gear position indicators utilize a group of lights.
    I. One type consist of group of three green lights, which illuminate when the landing gear is down and locked.
    II. Another type consist of one green light to indicate when landing gear is down and an amber light to indicate when the gear is up.
    III. Still other systems incorporate a red or amber light to indicate when the gear is in transit or unsafe for landing.
    IV. The lights are usually of the "press to test" type, and the bulbs are interchangeable.
- Other type of landing gear position indicators consist of tab-type indicators with markings "UP" to indicate the gear is up and locked, a display of red and white diagonal stripes to show when the gear is unlocked, or a silhouette of each gear to indicate when it locks in the DOWN position.

APPLICATION OF HYDRAULIC SYSTEM

Hydraulic system liquids are used primarily to transmit and distribute forces to various units to be actuated. Liquids are able to do this because they are almost incompressible. As Pascal's law states that pressure applied to any part of a confined liquid is transmitted with undiminished intensity to every other part.

The hydraulic system of the average modern aircraft performs many functions. Among the units commonly operated by hydraulic system are landing gear, wing flaps, speed and wheel brakes, and flight control surfaces.

Hydraulic system have many advantages as a power source for operating various aircraft units.

- Light weight
- Ease of installation
- Simplification of inspection
- Minimum maintenance requirement
- Fully efficient, with only negligible loss due to fluid friction
- Regardless of application, hydraulic system has minimum number of components

METHODOLOGY

The landing gear design and integration process encompasses knowledge of many engineering disciplines, kinematics, fluid mechanics and runway floatation. The geometry, floatation requirements, mission requirements and operational requirements of the aircraft govern the landing gear configuration.

The configuration design includes choice of number of wheels, tire size, 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 regulation.

In preliminary design phase, dynamic stimulations are carried out for the 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.

The landing gear manufacturing involves development of many closed die forgings, machined components from ultra-high strength steels, titanium and aluminium alloys. Precision tolerances are required for components like actuator cylinder, piston, shock absorber parts and axle. Heat treatment of parts is performed after rough machine followed by final machining, plating and painting. Reliability of the product is enhanced through stringent quality assurance requirements.

In-service evaluation includes evaluation in various types of airfield conditions and ambient conditions. Feedbacks on reliability and maintainability results are taken for further improvements in the system and data generation.

Landing gear technologies are continuously evolving to meet the challenges of functional and non-functional requirements. Some of these technologies are steering system, actuation system, brake system, tires, up-locks, materials,, corrosion protection, etc.

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

In actuation systems, more electric or all electric systems are replacing the conventional hydraulic systems. Electric systems help to overcome problems of leakage and fire hazard.

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

Landing gear radial tires offer lighter tire with longer life compared to bias ply tires.

Hydro-mechanical locking systems and proximity switches are replacing mechanical locks and micro-switches. They have higher reliability.

Composites are being used in some components of landing gear because of their superior specific strength and stiffness properties. Ultra-high strength steel are used due to its high strength to weight ratio and size advantage.

Good corrosion protection is important for landing gear components as they are susceptible for easy environmental attack. Use of corrosion resistant materials is also becoming increasingly popular.

CONCLUSION

Thus, we have successfully design, model and test a landing gear to provide a support for the plane when at rest on the ground, to provide a stable chassis for taxing or rolling during take-off and landing.

The need to design landing gear with minimum weight, minimum volume, high performance, improved life and reduced life cycle cost have posed many challenges to landing gear designers. Further, it is essential to reduce the landing gear design and development cycle time while meeting all the safety and regulatory requirements. Many technologies have been developed over the years to meet the challenges of landing gear design and development.

These technologies have matured over the years and widely used in the current landing gear system and new technologies will continue to evolve in future.

The future landing gear design for aircraft poses many new challenges in configuration design, use of materials, designs and analysis methods.