International Journal of Scientific Research in Science and Technology
Print ISSN: 2395-6011 | Online ISSN: 2395-602X (www.ijsrst.com)
doi : https://doi.org/10.32628/IJSRST

Analysis of Stress and Displacement of Landing Gear for an Aircraft Through the Finite Element Method

[1]Siva Sankar Kanchi, [2]C. Subhahan Basha, [3]Dr. P. Naresh
[1]M. Tech student, [2]Assistant professor, [3]Assistant professor and Head of the Department
[1,2,3]Department of Mechanical Engineering, GATES Engineering College, Gooty, Andhra Pradesh, India

Article Info
Volume 9, Issue 2
Page Number : 237-251

Publication Issue
March-April-2022

Article History
Accepted : 01 April 2022
Published : 09 April 2022

ABSTRACT

An aircraft landing gear system must absorb the kinematic energy produced by a landing impact and excitations caused by the aircraft travelling over an uneven runway surface. This is necessary requirement of successfully designed landing system. The oleo pneumatic shock is the most common type of shock absorber landing gear system used in aircraft. It dissipates the kinetic energy produced by impact arising when an airplane lands at high speed but also offer a comfortable rice to passenger when the airplane taxies at low speed. The objective of this project to determine the stress behavior and the displacement of a nose gear of an aircraft during landing using structural finite element analysis using with the help of analytical calculation. The external forces were determine analytical and the interactions between components were carefully modeled using contact analysis.

Keywords : Aircraft Landing Gear System, TAIL DRAGGER, Ar 234 jet

I. INTRODUCTION

Landing gear is the undercarriage of an aircraft or spacecraft and may be used for either takeoff or landing. For aircraft it is generally both. It was also formerly called alighting gear by some manufacturers, such as the Glenn L. Martin Company. For aircraft, the landing gear supports the craft when it is not flying, allowing it to take off, land, and taxi without damage. Wheels are typically used but skids, skis, floats or a combination of these and other elements can be deployed depending both on the surface and on whether the craft only operates vertically (VTOL) or is able to taxi along the surface. Faster aircraft usually have retractable undercarriages, which fold away during flight to reduce air resistance or drag. For launch vehicles and spacecraft Landers, the landing gear is typically designed to support the vehicle only post-flight, and are typically not used for takeoff or surface movement.

Aircraft landing gear:

Aircraft landing gear usually includes wheels equipped with simple shock absorbers, or more advanced air/oil oleo struts, for runway and rough terrain landing. Some aircraft are equipped with skis for snow or floats for water, and/or skids or pontoons helicopters.

It represents 2.5 to 5% of the MTOW and 1.5 to 1.75% of the aircraft cost but 20% of the airframe direct maintenance cost; each wheel can support up to 30 t (66,000 lb), reach over 300 km/h, roll up to 500,000 km (310,000 mi) ; it has a 20,000 hours' time between overhaul and a 60,000 hours or 20 years life time. The undercarriage is typically 4–5% of the takeoff mass and can even reach 7%.

Gear arrangements

Wheeled undercarriages normally come in two types:

- conventional or "tail dragger" undercarriage, where there are two main wheels towards the front of the aircraft and a single, much smaller, wheel or skid at the rear;
- Tricycle undercarriage where there are two main wheels (or wheel assemblies) under the wings and a third smaller wheel in the nose.

The tail dragger arrangement was common during the early propeller era, as it allows more room for propeller clearance. Most modern aircraft have tricycle undercarriages. Tail draggers are considered harder to land and take off (because the arrangement is usually unstable, that is, a small deviation from straight-line travel will tend to increase rather than correct itself), and usually require special pilot training. Sometimes a small tail wheel or skid is added to aircraft with tricycle undercarriage, in case of tail strikes during take-off. The Concorde, for instance, had a retractable tail "bumper" wheel, as delta winged aircraft need a high angle when taking off. Both Boeing's largest WWII bomber, the B-29 Super fortress, and the 1960s-introduced Boeing 727 trijet airliner each have a retractable tail bumper. Some aircraft with retractable conventional landing gear have a fixed tail wheel, which generates minimal drag (since most of the airflow past the tail wheel has been blanketed by the fuselage) and even improves yaw stability in some cases. Another arrangement sometimes used is central main and nose gear with outriggers on the wings. The B-52bomber uses a similar arrangement, except that each end of the fuselage has two sets of wheels side by side.

Gear arrangements

CONVENTIONAL "TAIL DRAGGER"

Retractable gear:

To decrease drag in flight some undercarriages retract into the wings and/or fuselage with wheels flush against the surface or concealed behind doors; this is called retractable gear. If the wheels rest protruding and partially exposed to the airstream after being retracted, the system is called semi-retractable.

Most retraction systems are hydraulically operated, though some are electrically operated or even manually operated. This adds weight and complexity to the design. In retractable gear systems, the compartment where the wheels are stowed are called wheel wells, which may also diminish valuable cargo or fuel space. Pilots confirming that their landing gear is down and locked refer to "three greens" or "three in the green.", a reference to the electrical indicator lights (or painted panels of mechanical indicator units) from the nosewheel/tailwheel and the two main gears. Blinking green lights or red lights indicate the gear is in transit and neither up and locked or down and locked. When the gear is fully stowed up with the up-locks secure, the lights often extinguish to follow the dark cockpit philosophy; some airplanes have gear up indicator lights.

Multiple redundancies are usually provided to prevent a single failure from failing the entire landing gear extension process. Whether electrically or hydraulically operated, the landing gear can usually be powered from multiple sources. In case the power system fails, an emergency extension system is always available. This may take the form of a manually operated crank or pump, or a mechanical free-fall mechanism which disengages the up locks and allows the landing gear to fall due to gravity. Some high-performance aircraft may even feature a pressurized-nitrogen back-up system.

Retractable gear:

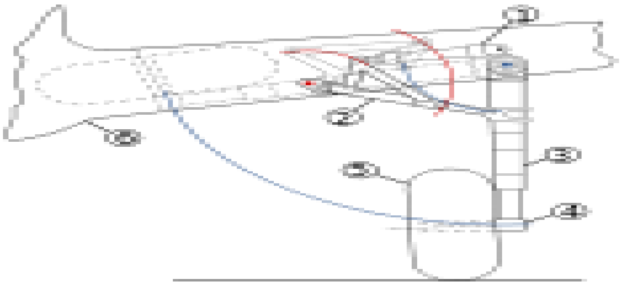
To decrease drag in flight some undercarriages retract into the wings and/or fuselage with wheels flush against the surface or concealed behind doors; this is called retractable gear. If the wheels rest protruding and partially exposed to the airstream after being retracted, the system is called semi-retractable.

Most retraction systems are hydraulically operated, though some are electrically operated or even manually operated. This adds weight and complexity to the design. In retractable gear systems, the compartment where the wheels are stowed are called wheel wells, which may also diminish valuable cargo or fuel space. Pilots confirming that their landing gear is down and locked refer to "three greens" or "three in the green.", a reference to the electrical indicator lights (or painted panels of mechanical indicator units) from the nose wheel/tail wheel and the two main gears. Blinking green lights or red lights indicate the gear is in transit and neither up and locked or down and locked. When the gear is fully stowed up with the up-locks secure, the lights often extinguish to follow the dark cockpit philosophy; some airplanes have gear up indicator lights.

Multiple redundancies are usually provided to prevent a single failure from failing the entire landing gear extension process. Whether electrically or hydraulically operated, the landing gear can usually be powered from multiple sources. In case the power system fails, an emergency extension system is always available. This may take the form of a manually operated crank or pump, or a mechanical free-fall mechanism which disengages the up locks and allows the landing gear to fall due to gravity. Some high-performance aircraft may even feature a pressurized-nitrogen back-up system.

ME 163B KOMET WITH ITS TWO-WHEEL TAKEOFF "DOLLY" IN PLACE

THE LANDING GEAR OF A BOEING 767 RETRACTING INTO THE FUSELAGE



Schematic Showing Hydraulically Operated Landing Gear, With The Wheel Stowed In The Wing Root Of The Aircraft

A Boeing 737-700 with main undercarriage retracted in the wheel wells without landing gear doors

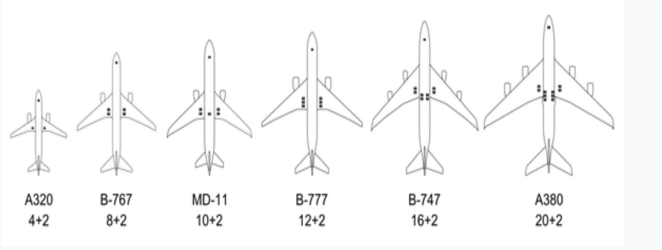
A Ju 87D with a wheel spat on its right wheel, absent on its left

Large aircraft:

As aircraft grow larger, they employ more wheels to cope with the increasing weights. The earliest "giant" aircraft ever placed in quantity production, the Zeppelin-Staaken R.VI German World War I long-range bomber of 1916, used a total of eighteen wheels for its undercarriage, split between two wheels on its nose gear struts, and a total of sixteen wheels on its main gear units - split into four side-by-side quartets each, two quartets of wheels per side - under each tandem engine nacelle, to support its loaded weight of almost 12 metric tons. Multiple "tandem wheels" on an aircraft - particularly for cargo aircraft, mounted to the fuselage lower sides as retractable main gear units on modern designs - were first seen during World War II, on the experimental German Arado Ar 232 cargo aircraft, which used a row of eleven "twinned" fixed wheel sets directly under the fuselage centerline to handle heavier loads while on the ground.[4] Many of today's large cargo aircraft use this arrangement for their retractable main gear setups (usually mounted on the lower corners of the central fuselage structure). The Airbus A340-500/-600 has an additional four-wheel undercarriage bogie on the fuselage centerline, much like the twin-wheel unit in the same general location, used on later DC-10 and MD-11 airliners.

The Boeing 747 has five sets of wheels: a nose wheel assembly and four sets of four-wheel bogies. A set is located under each wing, and two inner sets are located in the fuselage, a little rearward of the outer bogies, adding up to a total of eighteen wheels and tires. The Airbus A380 also has a four-wheel bogie under each wing with two sets of six-wheel bogies under the fuselage.

The world's largest jet cargo aircraft, the Soviet Antonov An-225 has 4 wheels on the twin-strut nose gear units (as its smaller "stablemate", the Antonov An-124 also uses), and 28 main gear wheel/tire units, adding up to a total of 32 wheels and tires.



Wheel arrangements of large airliners

Oleo strut rear landing gear of an Antonov An-124 (24 wheel landing gear)

The A340-600 has an additional main undercarriage on the fuselage belly

Wing and fuselage undercarriages on a Boeing 747-400, shortly before landing

1) Nautical:

Some aircraft have landing gear adapted to take off from and land on water. A floatplane has landing gear comprising two or more streamlined floats.

A flying boat has a lower fuselage possessing the shape of a boat hull giving it buoyancy, usually with a "step" near the center of gravity to allow the aircraft to more easily break free of the water's surface for takeoff. Additional landing gear is often present, typically comprising wing-mounted floats, or more rarely, stub-wing like sponsors on the lower sides of the fuselage, with their lower surfaces even with the chine’s forming the longitudinal lower corners of a flying boat's lower hull contours. Helicopters able to land on water may have floats or a hull. An amphibious aircraft has landing gear for both land and water-based operation.

Other types of landing gear

landing gear

When an airplane needs to land on surfaces covered by snow, the landing gear usually consists of skis or a combination of wheels and skis.

Detachable landing gear

Some aircraft use wheels for takeoff and then jettison them soon afterwards for improved aerodynamic streamlining without the complexity, weight and space requirements of a retraction mechanism. In these cases, the wheels to be jettisoned are sometimes mounted onto axles that are part of a separate "dolly" (for main wheels only) or "trolley" (for a three-wheel set with a nose wheel) chassis. Landing is then accomplished on skids or similar other simple devices.

Historical examples include the "dolly"-using Messerschmitt Me 163 Komet rocket fighter, the Messerschmitt Me 321 Gigant troop glider, and the first eight "trolley"-using prototypes of the Arado Ar 234 jet reconnaissance bomber. The main disadvantage to using the takeoff dolly/trolley and landing skid(s) system on German World War II aircraft – intended for a sizable number of late-war German jet and rocket-powered military aircraft designs – was that aircraft would likely be scattered all over a military airfield after they had landed from a mission, and would be unable to taxi on their own to an appropriately hidden "dispersal" location, which could easily leave them vulnerable to being shot up by attacking Allied fighters. A related contemporary example are the wingtip support wheels ("pogos") on the Lockheed U-2 reconnaissance aircraft, which fall away after take-off and drop to earth; the aircraft then relies on titanium skids on the wingtips for landing.

Rewards and sideways retraction

A Royal Air Force P-47 with its raked-forward main gear, and rearward-angled main wheel position (when retracted) indicated by the just-visible open wheel door.

Some main landing gear struts on World War II aircraft, in order to allow a single-leg main gear to more efficiently store the wheel within either the wing or an engine nacelle, rotated the single gear strut through a 90° angle during the rearwards-retraction sequence to allow the main wheel to rest "flat" above the lower end of the main gear strut, or flush within the wing or engine nacelles, when fully retracted. Examples are the Curtiss P-40, Vought F4U Corsair, Grumman F6F Hellcat, Messerschmitt Me 210 and Junkers Ju 88. The Aero Commander family of twin-engined business aircraft also shares this feature on the main gears, which retract aft into the ends of the engine nacelles. The rearward-retracting nosewheel strut on the Heinkel He 219 and the forward-retracting nose gear strut on the later Cessna Skymaster similarly rotated 90 degrees as they retracted.

On most World War II single-engined fighter aircraft (and even one German heavy bomber design) with sideways retracting main gear, the main gear that retracted into the wings was meant to be raked forward, towards the aircraft's nose in the "down" position for better ground handling, with a retracted position that placed the main wheels at some angle "behind" the main gear's attachment point to the airframe – this led to a complex angular geometry for setting up the "pintle" angles at the top ends of the struts for the retraction mechanism's axis of rotation, with some aircraft, like the P-47 Thunderbolt and Grumman Bearcat, even mandating that the main gear struts lengthen as they were extended down from the wings to assure proper ground clearance for their large four-bladed propellers. One exception to the need for this complexity in many WW II fighter aircraft was Japan's famous Zero fighter, whose main gear stayed at a perpendicular angle to the centerline of the aircraft when extended, as seen from the side.

Tandem layout:

Hawker Siddeley Harrier GR7 (ZG472). The two main wheels are in line astern under the fuselage, with a smaller wheel on each wing

An unusual undercarriage configuration is found on the Hawker Siddeley Harrier, which has two mainwheels in line astern under the fuselage (called a bicycle or tandem layout) and a smaller wheel near the tip of each wing. On second generation Harriers, the wing is extended past the outrigger wheels to allow greater wing-mounted munition loads to be carried, or to permit wing-tip extensions to be bolted on for ferry flights.

A multiple tandem layout was used on some military jet aircraft during the 1950s, pioneered by the Martin XB-51, and later used on such aircraft as the U-2, Myasishchev M-4, Yakovlev Yak-25, Yak-28, Sud Aviation Vautour, and the B-47 Stratojet because it allows room for a large internal bay between the main wheels. A variation of the multi tandem layout is also used on the B-52 Stratofortress which has four main wheel bogies (two forward and two aft) underneath the fuselage and a small outrigger wheel supporting each wing-tip. The B-52's landing gear is also unique in that all four pairs of main wheels can be steered. This allows the landing gear to line up with the runway and thus makes crosswind landings easier (using a technique called crab landing). Since tandem aircraft cannot rotate for takeoff, the forward gear must be long enough to give the wings the correct angle of attack during takeoff. During landing, the forward gear must not touch the runway first, otherwise the rear gear will slam down and cause the aircraft to bounce off the runway.

Crosswind landing accommodation:

The "castoring" main gear arrangement on a Blériot XI

One very early undercarriage arrangement that passively allowed for castoring during crosswind landings, unlike the "active" arrangement on the B-52, was pioneered on the Bleriot VIII design of 1908. It was later used in the much more famous Blériot XI

Channel-crossing aircraft of 1909 and also copied in the earliest examples of the Etrich Taube. In this arrangement the main landing gear's shock absorption was taken up by a vertically sliding bungee cord-sprung upper member. The vertical post along which the upper member slid to take landing shocks also had its lower end as the rotation point for the forward end of the main wheel's suspension fork, allowing the main gear to pivot on moderate crosswind landings.

Kneeling gear

One of the very first aircraft to use a "kneeling" function in its undercarriage design was the World War II German Arado Ar 232cargo/transport aircraft, produced in small numbers as both a twin-engine version, and one with four engines - both the nose gear, and the wing-mounted, inwards-retracting main landing gear were designed to have a "kneeling" function in their design to assist in loading/unloading cargo, and to also allow its unique, exposed fixed ventral fuselage-centerline set of eleven "twinned" auxiliary wheel sets to more firmly support the fuselage on soft ground, and to enable taxiing the aircraft over ditches and other ground obstacles.

Some early U.S. Navy jet fighters were equipped with “kneeling” nose gear consisting of small steerable auxiliary wheels on short struts located forward of the primary nose gear, allowing the aircraft to be taxied tail-high with the primary nose gear retracted. This feature was intended to enhance safety aboard aircraft carriers by redirecting the hot exhaust blast upwards, and to reduce hangar space requirements by enabling the aircraft to park with its nose underneath the tail of a similarly equipped jet. Kneeling gear was used on the North American FJ-1 Fury and on early versions of the McDonnell F2H Banshee, but was found to be of little use operationally, and was omitted from later Navy fighters.

The nosewheel gear systems of some large cargo jets, like the Antonov An-124 Condor, kneel to assist in loading and unloading of cargo using ramps through the forward, "tilt-up" hinged fuselage nose while stationary on the ground.

Monowheel:

A Schleicher ASG 29 glider shows its monowheel landing gear

To minimize drag, modern gliders usually have a single wheel, retractable or fixed, centered under the fuselage, which is referred to as monowheel gear or monowheel landing gear. Monowheel gear is also used on some powered aircraft, where drag reduction is a priority, such as the Europe XS. Much like the Me 163 rocket fighter, some gliders from prior to the Second World War used a take-off dolly that was jettisoned on take-off and then landed on a fixed skid. This configuration is necessarily accompanied with a tail dragger.

Helicopters:

Light helicopters tend to use simple landing skids to save weight and cost. They include attachment points for wheels so that they can be moved for short distances on the ground. Skids are impractical for helicopters weighing more than four tons. Some high-speed machines have retractable wheels, but most use fixed wheels for their robustness, and to avoid the need for a retraction mechanism.

Tailsitter:

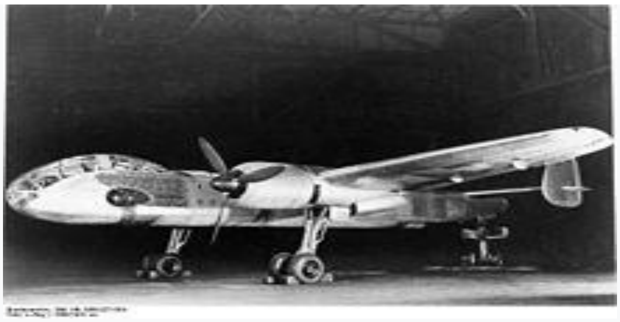
A Convair XFY Pogo showing its landing gear

Experimental tail sitter aircraft use landing gear located in their tails for VTOL operation.

Light aircraft:

For light aircraft a type of landing gear which is economical to produce is a simple wooden arch laminated from ash, as used on some homebuilt aircraft. A similar arched gear is often formed from spring steel. The Cessna Air master was among the first aircraft to use spring steel landing gear. The main advantage of such gear is that no other shock-absorbing device is needed; the deflecting leaf provides the shock absorption.

Folding gear:



Ju 288 V1 first prototype, showing its complex "folding" main undercarriage.

In order to save precious space, various folding and splayable landing gear designs have been created. The German Bomber B combat aircraft design competition winner, the Junkers Ju 288, had a complex "folding" main landing gear unlike any other aircraft designed by either Axis or Allied sides in the war: its single oleo strut was only attached to the lower end of its Y-form main retraction struts, handling the twinned main gear wheels, and folding by swiveling downwards and aft wards during retraction to "fold" the main gear's length to shorten it for stowage in the engine nacelle it was mounted in. However, the single pivot-point design also led to numerous incidents of collapsed main gear units for its prototype airframes.

2) Ground carriage

The idea behind a ground carriage is to leave the landing gear on the runway and not take it into the air, in order to reduce weight and drag. Examples include the "dolly" and "trolley" arrangements, respectively of the German Me 163B rocket fighter and Arado Ar 234A prototype jet recon-bomber designs of World War II, as their wheeled "ground carriages" were not usually allowed to either remain attached to the airframe, nor carried vary far away from the ground, during a normal takeoff procedure for either design.

3) Steering

There are several types of steering. Tail dragger aircraft may be steered by rudder alone (depending upon the prop wash produced by the aircraft to turn it) with a freely pivoting tail wheel, or by a steering linkage with the tail wheel, or by differential braking (the use of independent brakes on opposite sides of the aircraft to turn the aircraft by slowing one side more sharply than the other). Aircraft with tricycle landing gear usually have a steering linkage with the nose wheel (especially in large aircraft), but some allow the nose wheel to pivot freely and use differential braking and/or the rudder to steer the aircraft, like the Cirrus SR22.

Some aircraft require that the pilot steer by using rudder pedals; others allow steering with the yoke or control stick. Some allow both. Still others have a separate control, called a tiller, used for steering on the ground exclusively.

Rudder steering:

When an aircraft is steered on the ground exclusively using the rudder, turning the plane requires that a substantial airflow be moving past the rudder, which can be generated either by the forward motion of the aircraft or by thrust provided by the engines. Rudder steering requires considerable practice to use effectively. Although it requires air movement, it has the advantage of being independent of the landing gear, which makes it useful for aircraft equipped with fixed floats or skis.

Direct steering:

The nose gear steering-wheel (tiller) is visible as a semi-circular wheel to the left of the yoke in this photo of a Boeing 727 cockpit

Some aircraft link the yoke, control stick, or rudder directly to the wheel used for steering. Manipulating these controls turns the steering wheel (the nose wheel for tricycle landing gear, and the tail wheel for tail draggers). The connection may be a firm one in which any movement of the controls turns the steering wheel (and vice versa), or it may be a soft one in which a spring-like mechanism twists the steering wheel but does not force it to turn. The former provides positive steering but makes it easier to skid the steering wheel; the latter provides softer steering (making it easy to over control) but reduces the probability of skidding. Aircraft with retractable gear may disable the steering mechanism wholly or partially when the gear is retracted.

Differential braking:

Differential braking depends on asymmetric application of the brakes on the main gear wheels to turn the aircraft. For this, the aircraft must be equipped with separate controls for the right and left brakes (usually on the rudder pedals). The nose or tail wheel usually is not equipped with brakes. Differential braking requires considerable skill. In aircraft with several methods of steering that include differential braking, differential braking may be avoided because of the wear it puts on the braking mechanisms. Differential braking has the advantage of being largely independent of any movement or skidding of the nose or tail wheel.

Tiller steering:

A tiller in an aircraft is a small wheel or lever, sometimes accessible to one pilot and sometimes duplicated for both pilots, that controls the steering of the aircraft while it is on the ground. The tiller may be designed to work in combination with other controls such as the rudder or yoke. In large airliners, for example, the tiller is often used as the sole means of steering during taxi, and then the rudder is used to steer during takeoff and landing, so that both aerodynamic control surfaces and the landing gear can be controlled simultaneously when the aircraft is moving at aerodynamic speeds.

4) Tires and wheels

The specified selection criterion, e.g., minimum size, weight, or pressure, are used to select suitable tires and wheels from manufacturer's catalog and industry standards found in the Aircraft Yearbook published by the Tire and Rim Association, Inc.

II. MATERIALS USED FOR DESIGN

Titanium Alloy:

Titanium alloy has the highest specific strength (strength/weight ratio) of all metallic materials under 400 degree .C, it is also light, strong and corrosion resistant. New passenger jets are using an increasing ratio of Titanium alloy Ti- 6Al-4V, this material is used for aircraft components that require high strength, such as wing joints and landing gear. High efficiency machining of Titanium alloy is a challenge because its low thermal conductivity causes machining heat to concentrate on the edge of the cutting tool.

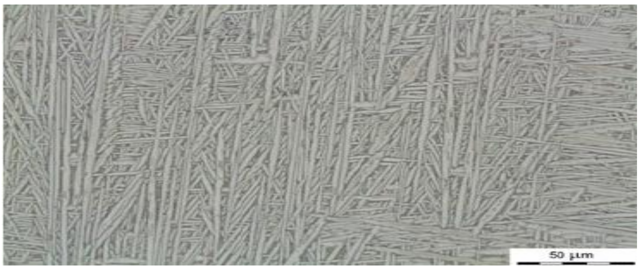
PERCENTAGECOMPOSITION OFTITANIUM ALLOY:

METALS	%COMPOSITION
ALUMINUM	6%
VANADIUM	4%
IRON	0.25%
TITANIUM	90%

OXGYEN	0.2

Percentage composition of Titanium Alloy

MICRO STRUCTURE OFTITANIUM ALLOY :



Titanium Alloy

PROPERTIES OF Titanium Alloy:

PROPERTY	VALUE
Density(kg/m3)	4512
Young's Modulus(MPa)	119000
Poisson's ratio	0.31

Properties of titanium alloy

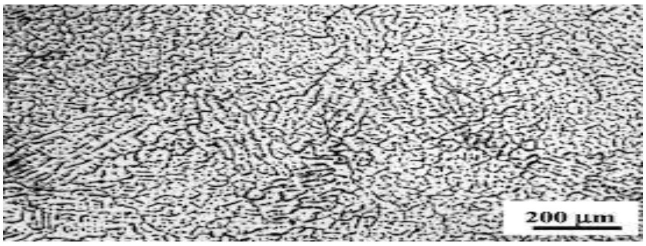
ALUMINIUM ALLOY:

PERCENTAGECOMPOSITION OFALUMINIUM ALLOY:

METALS	%COMPOSITION
ALUMINUM	91.21-93.5
BERYLIM	0.001
IRON	0.10
TITANIUM	0.06
COPPER	4.8-5.4
MAGNESIUM	0.7-1.1
MANGANESE	0.45-0.80
SILICON	0.08
SLIVER	0.40-0.70
ZINC	0.25
ZIRCONIUM	0.08-0.15

Percentage composition of ALUMINIUM ALLOY

MICRO STRUCTURE OFALUMINIUM ALLOY:



ALUMINIUM ALLOY

PROPERTIES OF ALUMINIUM ALLOY:

PROPERTY	VALUE
Density(Kg/m3)	2810
Young's Modulus(MPa)	73100
Poisson's ratio	0.33

Properties of ALUMINIUM ALLOY

Steel Alloy:

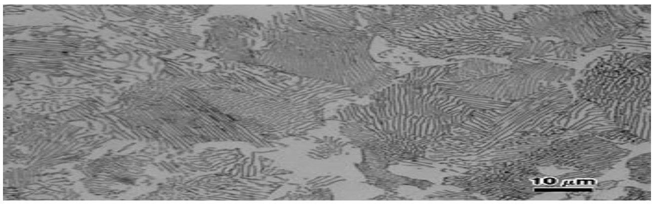
In steel alloys, ferrium m54 turns out to be a good material to use but also ferrium s53 and aermet 100 were also tested. The results shows that these three are not so different in results but ferrium m54 is somewhat better than other two so ferium m54 was selected as steel.

PERCENTAGECOMPOSITION OFSteel Alloy:

METALS	%COMPOSITION
Chrominium	18
Nickel	8-10

Percentage composition of Steel Alloy

MICRO STRUCTURE OFSteel Alloy:



Steel Alloy

PROPERTIES OF Steel Alloy:

PROPERTY	VALUE
Density(kg/m3)	7980
Young's Modulus(MPa)	204000
Poisson's ratio	0.29

Properties of Steel Alloy

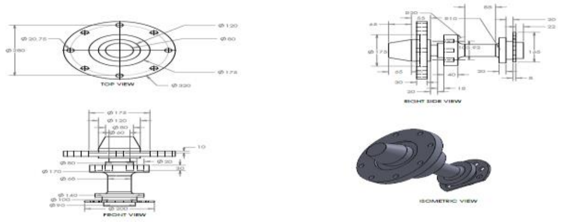
III. MODELING OF LANDING GEAR USING CREO

INTRODUCTION TO CREO:

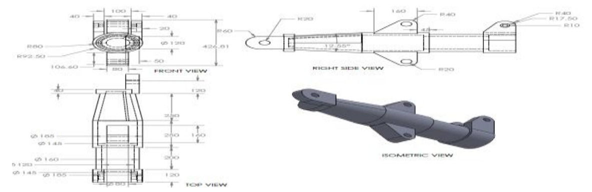
CREO is a powerful software which is a combination of various designing tools. It is popularly used by many leading manufacturing companies across the globe. It was designed by PTC (Parametric Technology Corporation). CREO is one of the most popular and powerful designing tools used in the market. With the popularity of CREO the demand of CREO certification has also increased in the market.

LANDING GEAR DESIGN:

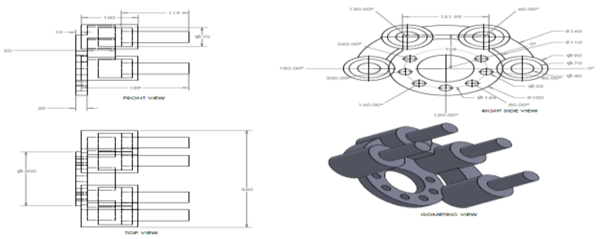
AXLE DESIGN:



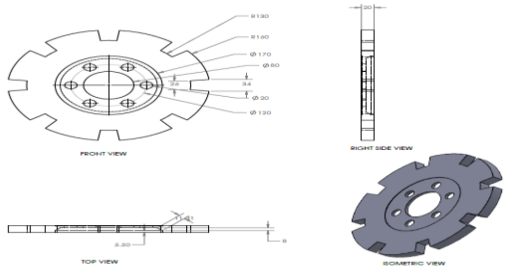
CYLINDERDESIGN:



DISCDESIGN:

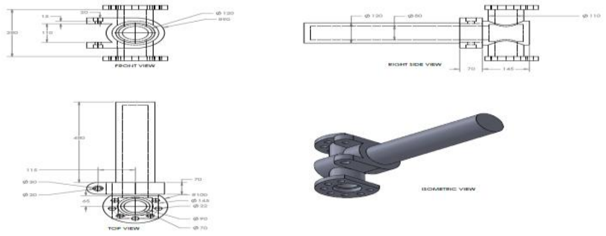


DISC PLATEDESIGN:

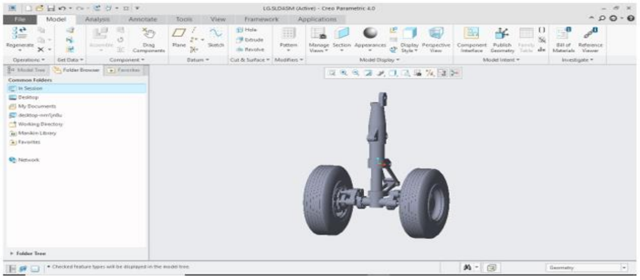


.LINK LOWER DESIGN:

PISTON DESIGN:



ASSEMBELY OF LANDING GEAR:



INTRODUCTION TO FEA:

The finite element analysis was the first developed in 1943 by R. Courant (Mathematician), who utilized the Ritz method on numerical analysis and minimization of variation calculus to obtain approximate solutions to vibration systems. Shortly thereafter, a paper published in 1956 M.J. Turner (air craft industry), R.W. Clough (California University), H.C. Martin (air craft industry) and L.J. Top established a broader definition of numerical analysis.

IV. INTRODUCTION TO ANSYS SOFTWARE

Ansys was founded in 1970 by John Swanson. Swanson sold his interest in the company to venture capitalists in 1993. Ansys went public on NASDAQ in 1996. In the 2000s, Ansys made numerous acquisitions of other engineering design companies, acquiring additional technology for fluid dynamics, electronics design, and other physics analysis.

It develops and markets engineering simulation software. Ansys software is used to design products and semiconductors, as well as to create simulations that test a product's durability, temperature distribution, fluid movements, and electromagnetic properties. Ansys develops and markets finite element analysis software used to simulate engineering problems. The software creates simulated computer models of structures, electronics, or machine components to simulate strength, toughness, elasticity, temperature distribution, electromagnetism, fluid flow, and other attributes. Ansys is used to determine how a product will function with different specifications, without building test products or conducting crash tests.

MECHANICAL PROPERTIES OF THE MATERIALS:

PROPERTY	Aluminium alloy	Titanium alloy	Steel alloy
Density	2780 Kg /m³	4512 Kg/m³	7980 Kg/m³
Young's modulus	73100 MPa	119000 MPa	204000MPa
Poison's ratio	0.33	0.31	0.29

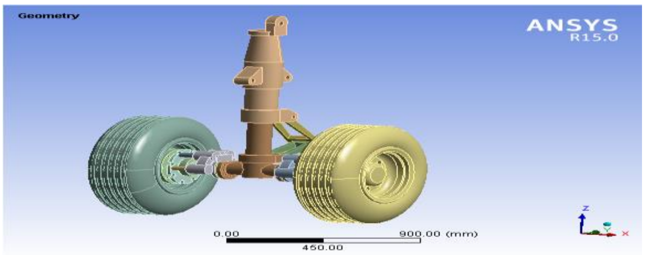
Mechanical properties of the materials

STRUCTURAL BOUNDARY CONDITIONS:

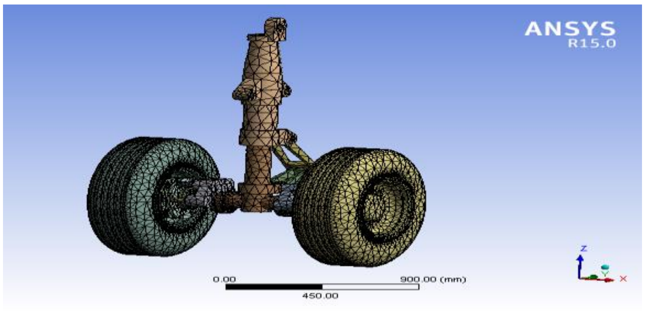
Specifications Of Boeing 747-8:

SNo.	NAME	WEIGHT (Kg)
1	Maximum take-off weight	4400 00
2	Maximum landing weight	306200
3	Operating empty weight	211900
4	Maximum zero fuel weight	288000

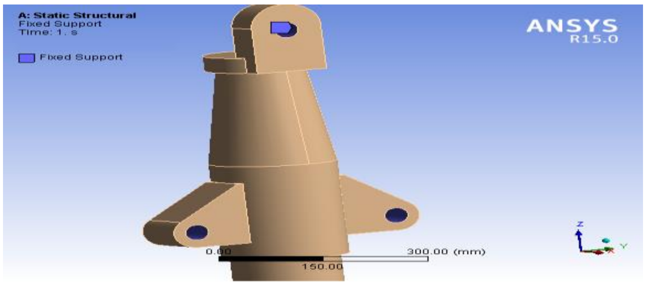
- Taking maximum take-off weight into account a static load of 80850 N has been chosen.
- Max take-off weight is 440000 kg and nose landing gear feels 5% of total weight which is 22000 kg so a 215600 N
- as the weight of whole design was 190 kg and actual nose landing gear have 1500 kg weight
- The weight taken is eight times lighter so 215600/8 *3 = 80850 N (taken F.O.S = 3).
- total force of 80850 N is applied to both sides centre nodes 40425 N each
- Total force=40425N



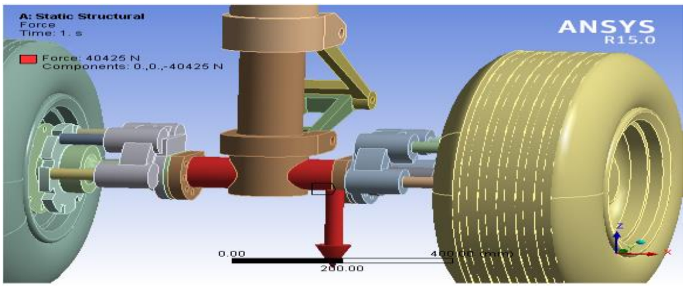
IGES file



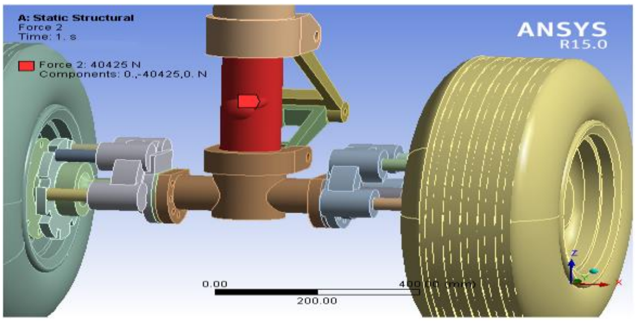
Meshed model



Fixed support

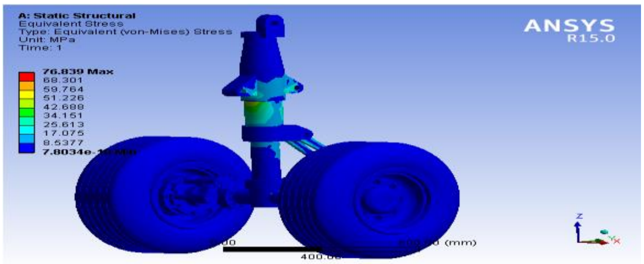


Force 1

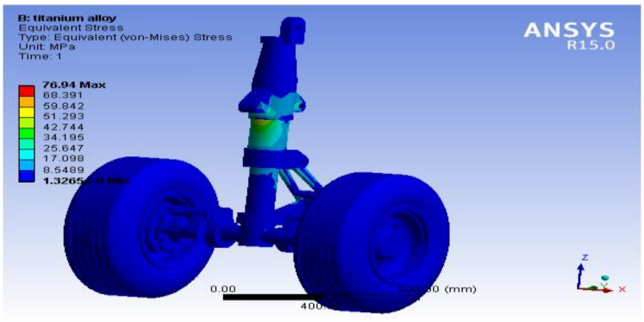


Force 2

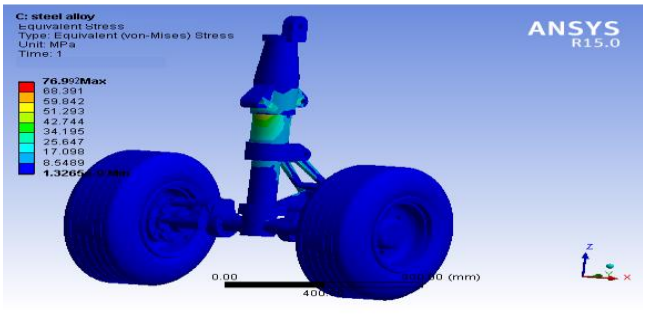
STRESS ANALYSIS:



Aluminium alloy

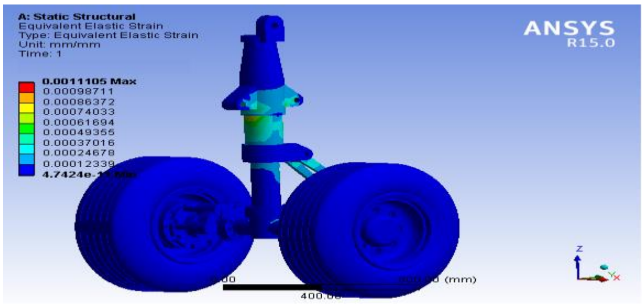


Titanium alloy

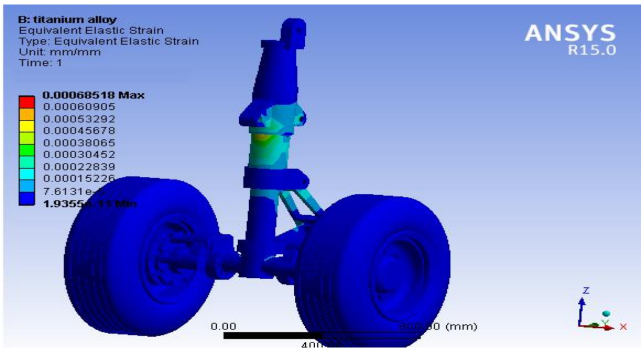


Steel alloy

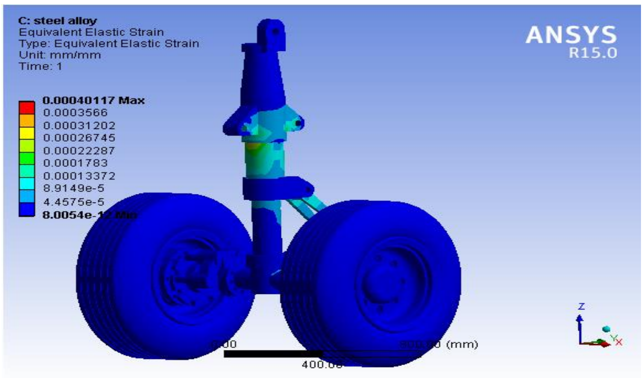
STRAIN ANALYSIS:



Aluminium alloy

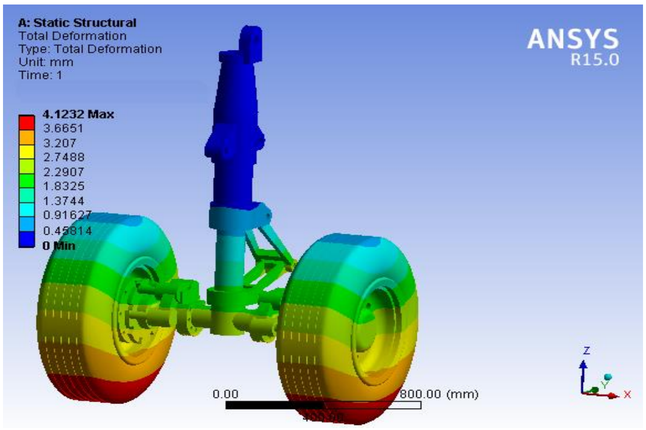


Titanium alloy

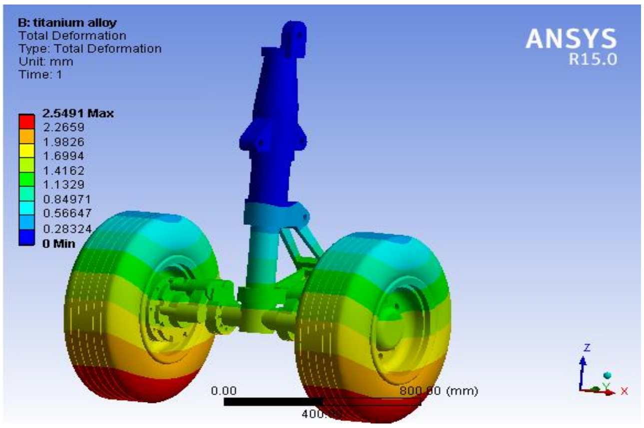


Steel alloy

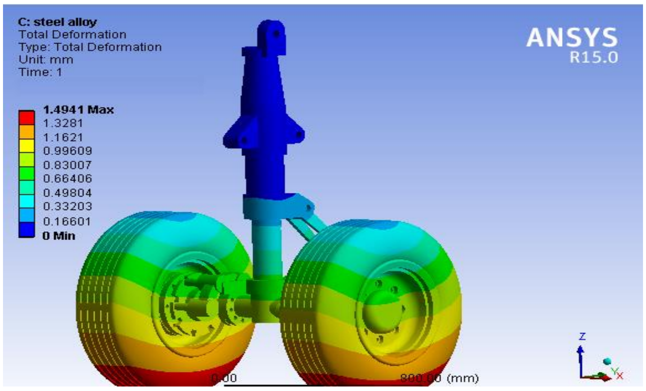
TOTAL DEFORMATION:



Aluminium alloy



Titanium alloy



Steel alloy

V. RESULTS FOR STRUCTURAL ANALYSIS

MATERIAL	TOTAL DEFORMATION (mm)	EQUIVALENT STRESS (MPa)	EQUIVALENT STRAIN
Aluminium alloy	4.1232	76.839	0.0011105
Titanium alloy	2.5491	76.94	0.00068518
Steel alloy	1.4941	76.992	0.00040117

Results for Structural analysis

VI. CONCLUSION

In this project, we have done structural analysis on the designed LANDING GEAR by changing materials of the landing gear (i.e., aluminum alloy, titanium alloy, steel alloy). The results are as follows:

From the results tables we observe that

- Total deformation and equivalent strain are less for steel alloy when compared with aluminum alloy and titanium alloy. Equivalent stress is more for steel alloy and titanium alloy.
- Thus, we conclude that steel alloy is the best material for manufacturing of landing gear.

FUTURE SCOPE

- In this project, only the static structural analysis on landing gear has been performed by the use of the software ANSYS15.0.
- This work can be extended to study the effect of load on the landing gear under dynamic conditions.
- Experimental stress analysis can be used to compare the different values obtained.
- The further study can be extended to transient structural, modal analysis and dynamic analysis of the landing gear.

VII.REFERENCES

[1]. M. Imran, S. A. R. M, M. Haneef, P. G. Student, M. Engineering, and G. College, “Static and Dynamic Response Analysis for Landing Gear of Test Air Crafts,” vol. 3, no. 5, 2014.

[2]. P. Kabade and R. Lingannavar, “Design and analysis of landing gear lug attachment in an airframe,” vol. 2, no. 10, pp. 5358–5370, 2013.

[3]. S. R. Basavaraddi, “Design and Analysis of Main Landing Gear Structure of a Transport Aircraft and Fatigue Life Estimation,” no. July, pp. 10–14, 2013.

[4]. A. V Gaikwad, R. U. Sambhe, and P. S. Ghawade, “Modeling and Analysis of Aircraft Landing Gear : Experimental Approach,”vol. 2, no. 7, pp. 2–5, 2013.

[5]. K. Shahapurkar and R. B. G, “Stress Analysis of an Aircraft Wing with a Landing Gear Opening Cutout of the Bottom Skin,” vol. 2, no. 5, pp. 406–412, 2014.

[6]. T. Global and L. Gear, “Introduction to Landing Gear.”

[7]. Praveen Joel P and Dr. Vijayan R, “Design and Stress Analysis of Nose Landing Gear Barrel (NLGB) of a typical naval trainer aircraft,” IOSR J. Mech. Civ. Eng., vol. 11, no. 2, pp. 67–74, 2014.

[8]. A. Rajesh and B.T.Abhay, “Design and Analysis Aircraft Nose and Nose Landing Gear,” Int. J. Eng. Sci., pp. 2319– 1813, 2015.

[9]. S. R. Basavaraddi, K. Manonmani, and P. M. Swami, “Stress and Fatigue Analysis of Landing Gear Axle of a,” pp. 224–228, 2015.

[10]. Mohammed Imran, Shabbir Ahmed R.M and Dr. Mohamed Haneef, “Static and dynamic

response analysis for landing gear of test aircrafts”, IJIRSET, vol. 3, issue 5, may 2014.

Cite this article as :

Siva Sankar Kanchi, C. Subhahan Basha, Dr. P. Naresh , "Analysis of Stress and Displacement of Landing Gear for an Aircraft Through the Finite Element Method", International Journal of Scientific Research in Science and Technology (IJSRST), Online ISSN : 2395-602X, Print ISSN : 2395-6011, Volume 9 Issue 2, pp. 237-251, March-April 2022.
Journal URL : https://ijsrst.com/IJSRST229244