CAE AND APPLICATION FEA REPORT

To: Sir Richard Nwawe Tchadeu

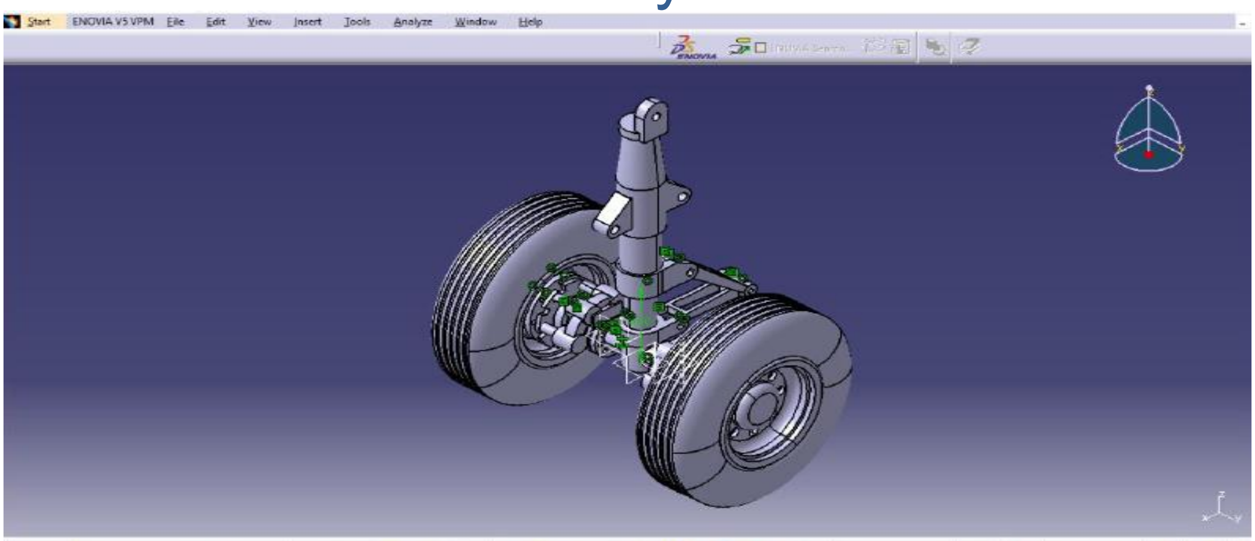
By: Muhammad Hamza

S.no: 23038506

Dept.: Mechanical Engineering

Structural Analysis and Material Selection for Aircraft landing Gear

“A Study on Aluminum Alloy 7075, Titanium 6A14v and Alloy Steel 4340”



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1. Introduction

Landing gear plays a crucial role in an aircraft's operation during both ground movements and takeoff. It has been observed that a significant number of aircraft structural failures are directly linked to issues within the landing gear system.

A landing gear must withstand considerable compressive loads, in addition to smaller drag and side loads. Due to the relatively low magnitude of drag and side loads, the landing gear is often considered a one-dimensional structure. Its design focuses on absorbing the energy from landing impacts to reduce the stress transferred to the aircraft's structure. While static strength is essential, the ability to absorb energy is equally critical in the design process. Simple leaf spring landing gears are adequate for smaller aircraft, but larger aircraft require the more sophisticated oleo pneumatic landing gear struts for effective energy absorption.

In our study, we utilized CATIA V5R20 to design a standard aircraft landing gear and conducted a structural safety analysis using CATIA. The design load was determined based on the maximum expected load. We analyzed the landing gear assembly using traditional metallic materials, including Aluminum Alloy 7075, Alloy Steel 4340, Titanium 6AL-4V, Titanium 6AL-6V-2Sn, and Titanium 10V-2Fe-3Al, employing CATIA software for stress and deflection assessments.

After importing the designed landing gear into CATIA for analysis, we compared the performance of the materials mentioned above. The Titanium alloy 10V-2Fe-3Al outperformed the others, exhibiting the highest safety factor and the lowest maximum stress values. Consequently, we recommend using titanium alloys to enhance the structural integrity of aircraft landing gear systems and minimize the risk of failures.

2. Literature Review

The landing gear serves as a critical foundation for an aircraft during both landing and ground operations, connecting directly to the aircraft's primary structural components. Acting as a bridge between the aircraft and the ground, the landing gear bears the brunt of all ground-related loads, transferring them safely to the aircraft's frame. Its pivotal roles include absorbing the energy during landing, facilitating braking, and enabling control during taxiing. Without an effective landing gear system, the dissipation of energy upon landing would be compromised, leading to potential damage to the airframe over time.

The structural configuration of the landing gear mirrors the quarter-car model found in automobiles, comprising three essential elements: mass, spring, and damper. In this specific situation, the airplane's weight addresses the mass, while the consolidated activity of gas and liquid inside the framework fills in as the spring and damper, separately. The plan and design of the arrival gear are decisively evolved considering these parts, guaranteeing that the framework meets the particular prerequisites of burden appropriation, ground soundness, and mobility.

The essential goal of the arrival gear is to offer a strong suspension framework that works effectively during take-off, landing, and navigating stages. By retaining and scattering the active energy from the arrival influence, the arrival gear altogether lessens the heap communicated to the airframe, defending its underlying honesty. Moreover, the arrival gear is furnished with a wheel slowing mechanism to decelerate the airplane and a wheel controlling system to coordinate the airplane on the ground. To improve streamlined productivity during flight, the arrival gear is intended to be retractable, limiting drag.

An extensive landing gear framework includes different underlying and mechanical parts fundamental for its activity. Primary parts incorporate the fundamental fitting, safeguards, bogie shaft or following arm, pivot, force arm, drag or side supports, withdrawal actuator, down and up-lock components, wheels, tires, and that's only the tip of the iceberg. In the meantime, the framework parts are contained the brake unit, antiskid framework, and the parts of the withdrawal framework. Together, these components structure a refined framework intended to guarantee the security, steadiness, and execution of the airplane during ground tasks, epitomizing a basic part of flight designing.

When it comes to the operation of an aircraft, as well as during ground movements and takeoff, landing gear is an extremely important component. The landing gear system has been observed to be directly responsible for a significant proportion of aircraft structural failures. This has been observed to be the case.
Additionally to being able to handle lesser drag and side pressures, a landing gear must also be able to bear significant compressive loads. It is common practice to consider the landing gear to be a one-dimensional construction because of the tiny amount of drag and side loads that it experiences. It is designed to absorb the energy that is delivered from landing impacts in order to lessen the amount of stress that is imparted to the structure of the aircraft. When it comes to the design process, the ability to absorb energy is just as important as the static strength of the material. The use of straightforward leaf spring landing gears is sufficient for smaller aircraft; however, in order to effectively absorb energy, larger aircraft require the more complex oleo pneumatic landing gear struts.

In CATIA, the collecting order is utilized to coordinate all of the recently designed components in order to come to a conclusion regarding the plan of the arriving gear. For the purpose of achieving a comprehensive and practical landing gear plan, this interaction is essential. Immediately after the gathering, a static investigation is going to be administered. This inquiry is vital for determining the displacements, stresses, strains, and powers that occur within the components when they are subjected to loads that do not significantly affect the damping and dormancy of the material. After taking into account the evaluation of the effects of various types of stacking, such as remotely applied powers and tensions, steady inertial powers such as gravity or rotational powers, predefined relocations, and temperature variations that lead to warm strain, assumptions are made regarding the conditions under which stacking occurs consistently.

Landing gear is an essential component of the foundation of an aero plane since it is directly connected to the fundamental structural components of the aircraft. This association makes landing gear an essential component. Both the landing and the ground operations are affected by this condition. As the component of the aircraft that is responsible for bearing the majority of all ground-related loads and transferring them to the frame of the aircraft in a secure manner, landing gear is the component that is responsible for this responsibility. It has the function of establishing a connection between the aero plane and the ground below while it is in flight. Some of the most important functions that it handles are the absorption of energy during landing, the facilitation of braking, and the accomplishment of control during taxiing or landing. These are only some of the responsibilities that it fulfils. In the absence of an efficient landing gear system, the absorption of energy during landing would be hindered, which might potentially result in damage to the airframe on subsequent landings from the aircraft. Due to the fact that the airframe would be vulnerable to damage, this would be a challenging situation.
It is feasible to draw parallels between the structural configuration of the landing gear and that of

the quarter-car type that is utilized in automobiles. It has been determined that the mass, the spring, and the damper are the three fundamental components that are responsible for the structural formation of this structure. The mass in this particular instance is determined by the weight of the aero plane, which is the factor that is accountable for addressing the quantity. On the other hand, the spring and damper functions are respectively performed by the combined activity of gas and liquid within the framework. These components are taken into consideration to a great degree during the process of establishing the concept and design of the arrival gear. Consequently, as a consequence of this, the framework will be able to satisfy the specific requirements of load appropriation, ground soundness, and mobility.

3. Material selection

Based on the following properties material selection process will be analyzed.

Aluminum Compound 7075 is a favored material in the aviation area because of its mix of daintiness and significant elasticity, credited predominantly to its significant zinc and copper content. This alloy boasts a tensile strength of 540 MPa and a melting point of 635°C, maintaining its mechanical properties even at low temperatures.

- Density: 2.88 Kg/m^3
- Poisson’s ratio: 0.33
- Yield strength: 95 MPa
- Young’s modulus: 80 GPa

Alloy Steel 4340 stands out for its exceptional strength, toughness, and fatigue resistance, derived from its composition that includes nickel, chromium, and molybdenum. This makes it highly workable into various shapes without compromising on strength. It exhibits a tensile strength of 1863 MPa and retains its properties well at low temperatures with a melting point of 1427°C.

- Density: 7.7 Kg/m^3
- Poisson’s ratio: 0.33
- Yield strength: 472.3 MPa
- Young’s modulus: 200 GPa

Titanium 6AL-4V, or Grade 5 Titanium, is the most broadly used titanium amalgam, offering better strength over financially unadulterated titanium while holding comparative solidness and warm properties. Prominently, it is heat treatable, weldable, and has incredible strength and consumption obstruction.

- Density: 4.43 Kg/m^3
- Poisson’s ratio: 0.342
- Yield strength: 880 MPa
- Young’s modulus: 113.8 GPa

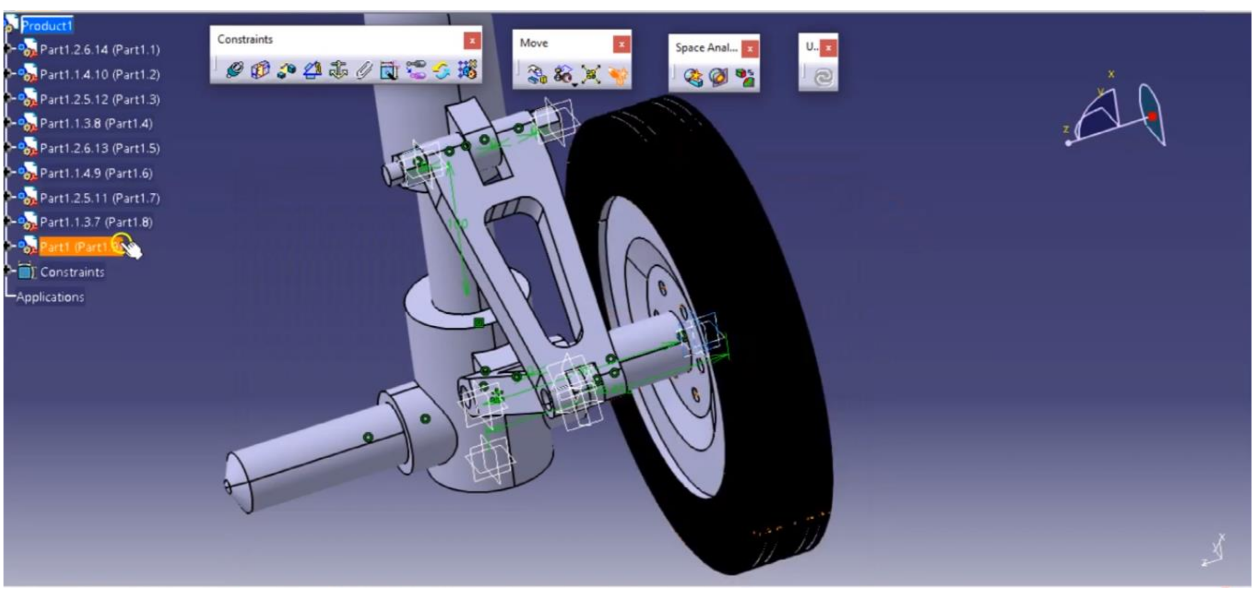
Titanium 6AL-6V-2Sn is known for its high strength, however it has somewhat lower durability and pliability contrasted with Titanium 6AL-4V. It stays a decision material for utilizes something like 400 degrees Celsius, bragging a rigidity 1000 MPa.

- Density: 4.54 Kg/m^3
- Poisson’s ratio: 0.30
- Yield strength: 980 MPa
- Young’s modulus: 110.3 GPa

Titanium 10Al-2Fe-3V, utilized in airplane landing gear frameworks, essentially lessens the airplane's weight — by roughly 600 pounds — contrasted with steel, because of its higher solidarity to-weight proportion. This high-strength combination, made out of titanium, aluminum, iron, and vanadium, shows an elasticity of 1170 MPa and a yield strength of 1050 MPa, with a liquefying point of 1649°C. Its high consumption obstruction guarantees strength under different circumstances.

- Density: 4.65 Kg/m^3
- Poisson’s ratio: 0.32
- Yield strength: 1050 MPa
- Young’s modulus: 108 GPa

Every one of these materials is picked in light of their extraordinary properties, like strength, thickness, consumption obstruction, and capacity to keep up with execution under temperature varieties, making them reasonable for explicit applications inside the aeronautic trade. Their determination is basic for upgrading the exhibition, security, and life span of aviation parts, particularly in basic frameworks like landing gears.



However, in view of the above material determination properties, we will pick Compound Steel 4340 stands apart for its uncommon strength, sturdiness, and exhaustion obstruction, got from creation incorporates nickel, chromium, and molybdenum.

4. Structural analysis

To settle the plan of the arrival gear in CATIA, the gathering order is utilized to coordinate all recently planned parts. This interaction is fundamental for accomplishing an exhaustive and utilitarian landing gear plan. Following the get together, a static investigation is directed. This investigation is pivotal for assessing the relocations, stresses, strains, and powers inside the parts under loads that don't essentially influence dormancy and damping. Presumptions of consistent stacking conditions are made, taking into account the appraisal of the impacts of different sorts of stacking, for example, remotely applied powers and tensions, steady inertial powers like gravity or rotational powers, predefined relocations, and temperature varieties that lead to warm strain.

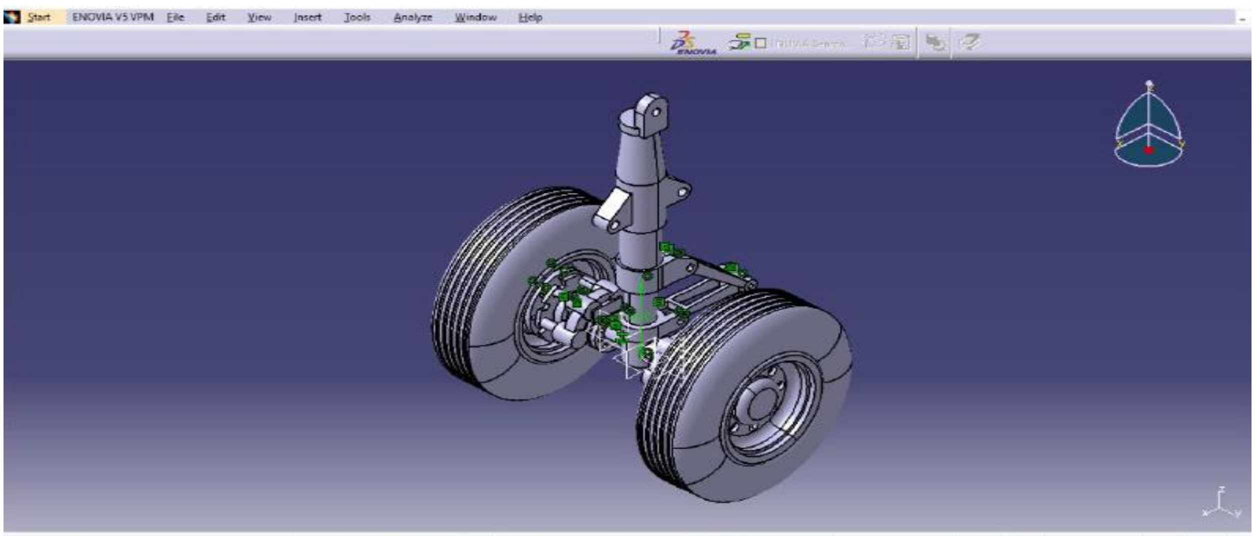
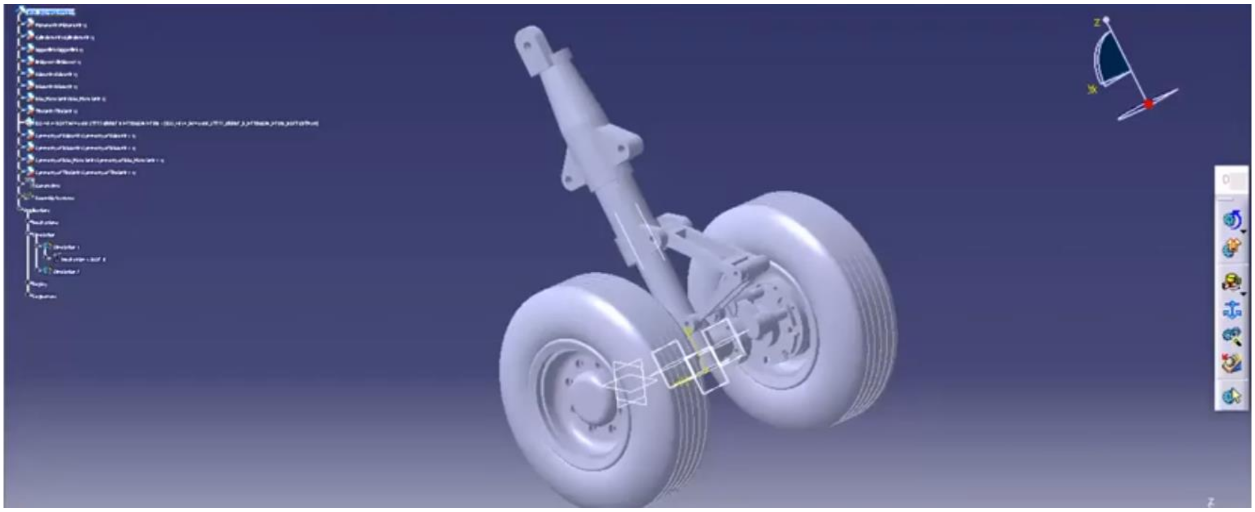


FIGURE 1: MODEL DESIGN OF LANDING GEAR USING CATIA SOFTWARE

For additional comprehension the dependability and avoidance of the construction, primary and modular investigations are embraced. Limited Component Examination (FEA) assumes an essential part in this stage, separating the design into an assortment of discrete substances alluded to as components. These components are interconnected at explicit intersections known as hubs. Applying stacked limit conditions to these components and hubs empowers an itemized assessment of the design.



The idea of lattice is presented here, where the math is partitioned spatially into components and hubs, framing a cross section. This cross section, joined with the material properties, really addresses the dissemination of firmness and mass all through the construction. The assurance of the default component size is impacted by a few elements, including the size of the general model, the closeness to different calculations, the curve of the body, and the intricacy of the plan highlights.

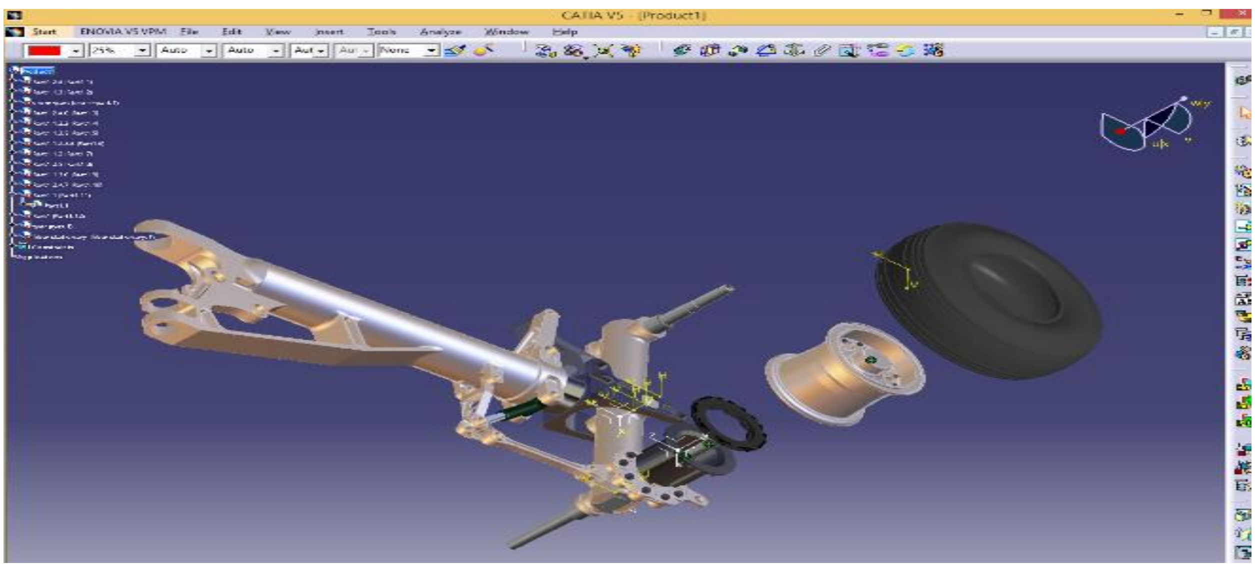
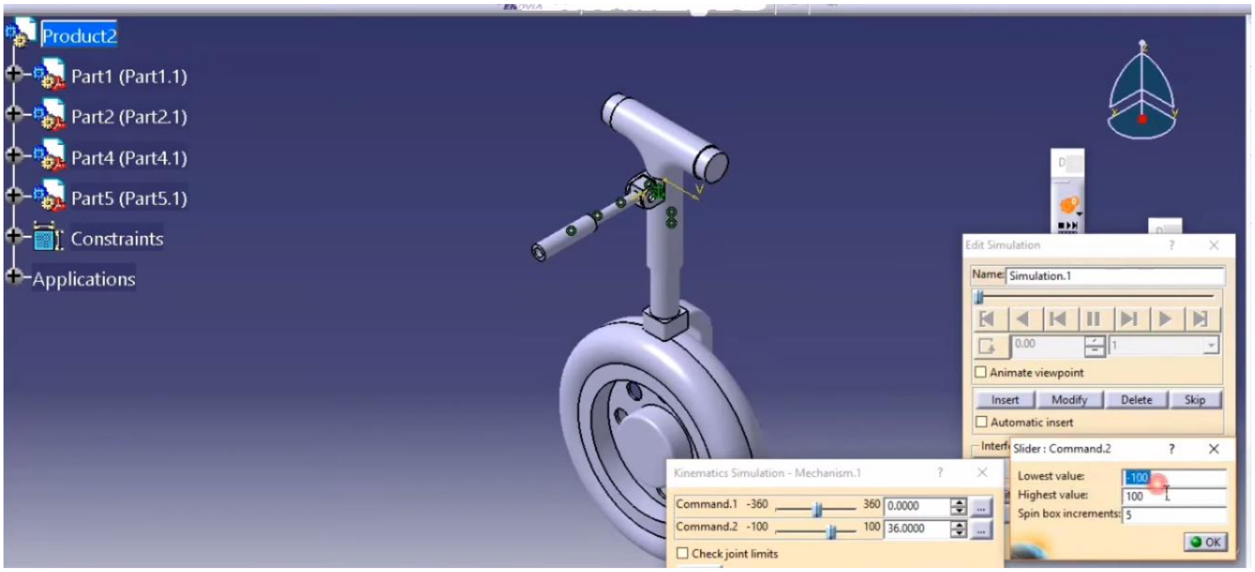


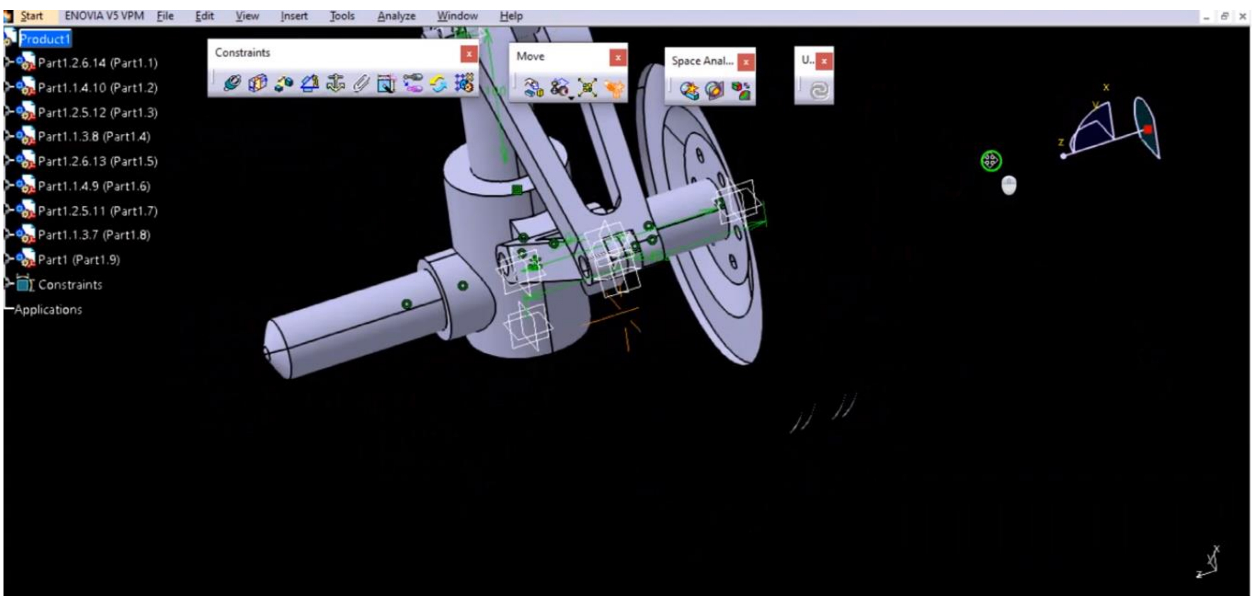
FIGURE 2: ANALYSIS OF LANDING GEAR

Through these procedures, engineers can unequivocally mimic and examine the way of behaving of the arrival gear under different circumstances. This extensive methodology guarantees that the plan meets the necessary determinations as well as streamlines the exhibition and security of the arrival gear in certifiable functional circumstances.



5. Model analysis

Following the foundation of the limited component model, the following basic step includes the utilization of limit conditions and loads. This stage permits clients to determine different imperatives and burdens, each being relegated a one of a kind set ID for proficient administration and following of various burden cases.



Limit conditions include a lot of different factors, like forces, pressure, pace, support systems, requirements, and other important limits for a full probe.

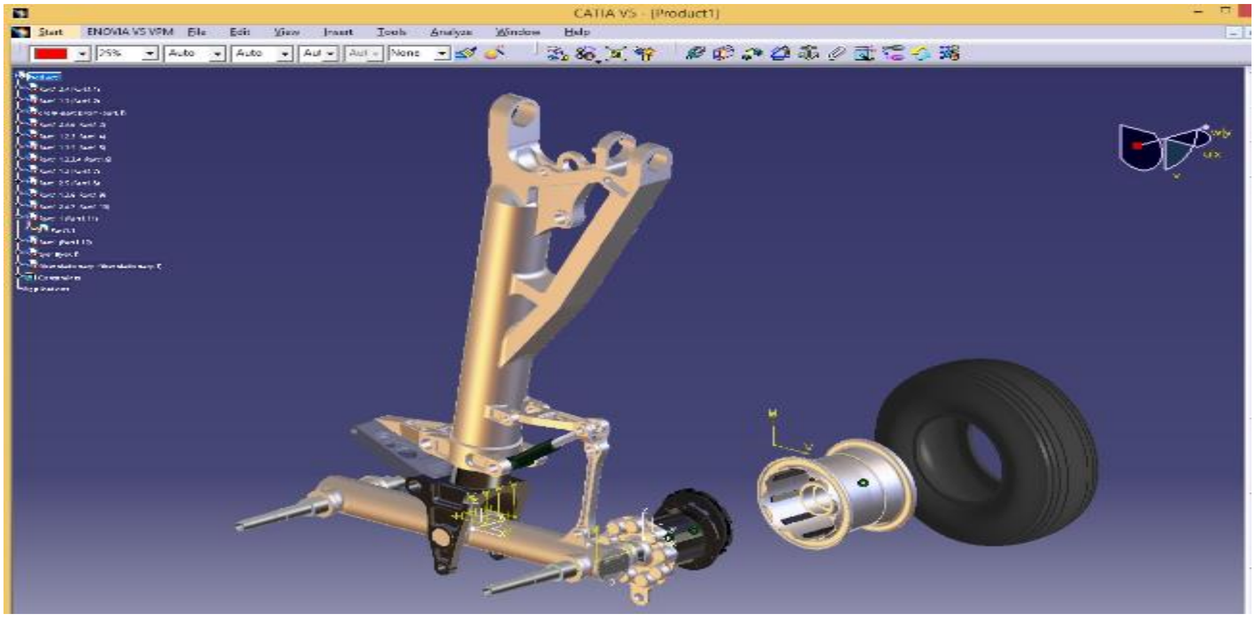
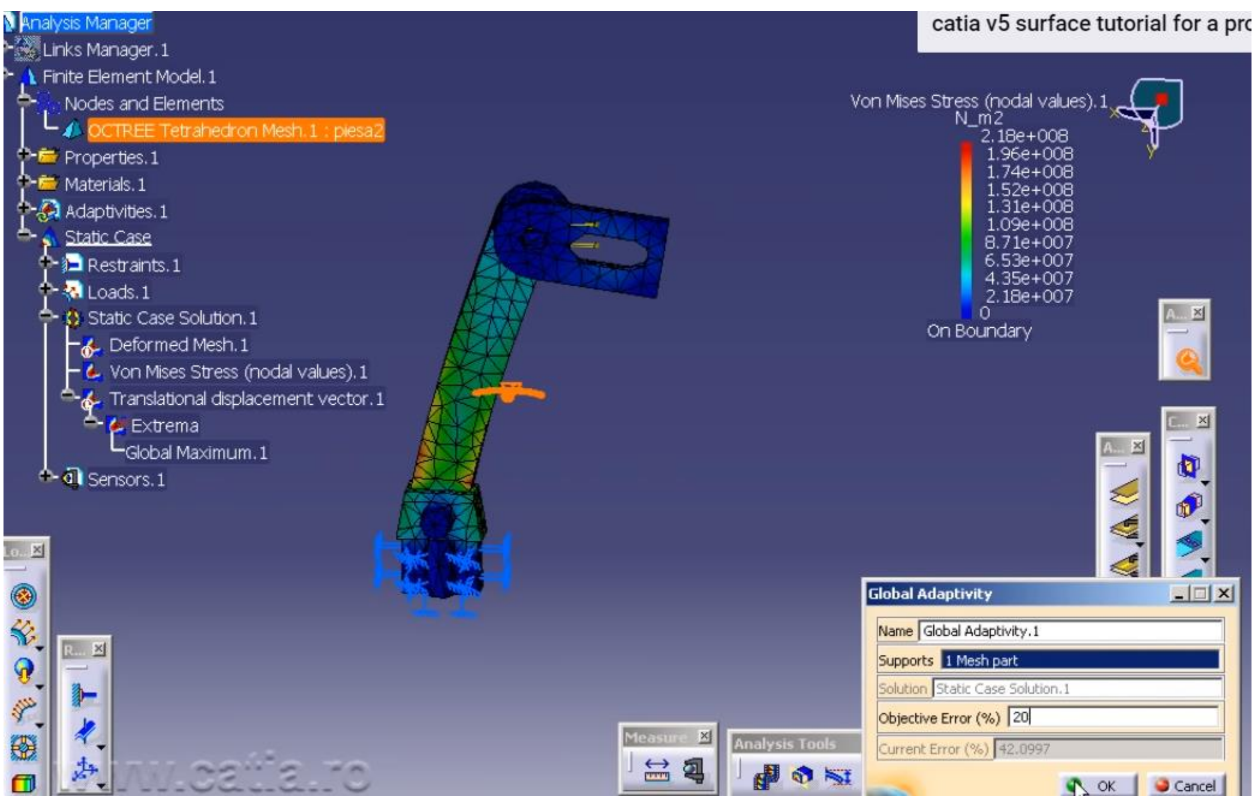


FIGURE 3: MODEL ANALYSIS

One of the more difficult facets of the probe interaction is putting limit conditions into motion. It requires careful attention to detail while putting limits and burdens on the parts to make sure that the recreation results are accurate and reliable. With the planned aerodynamics in mind, an upward heap from 1000kN is predicted to act in the oleo chamber's highest point. For this pile to fit, a good support is clearly placed at both the wheels and the top, where the pile is put down.



This plan is meant to replicate the real conditions the arrival cargo would face during landing, allowing a fair and thorough evaluation of its basic dependability and performance when under pressure.

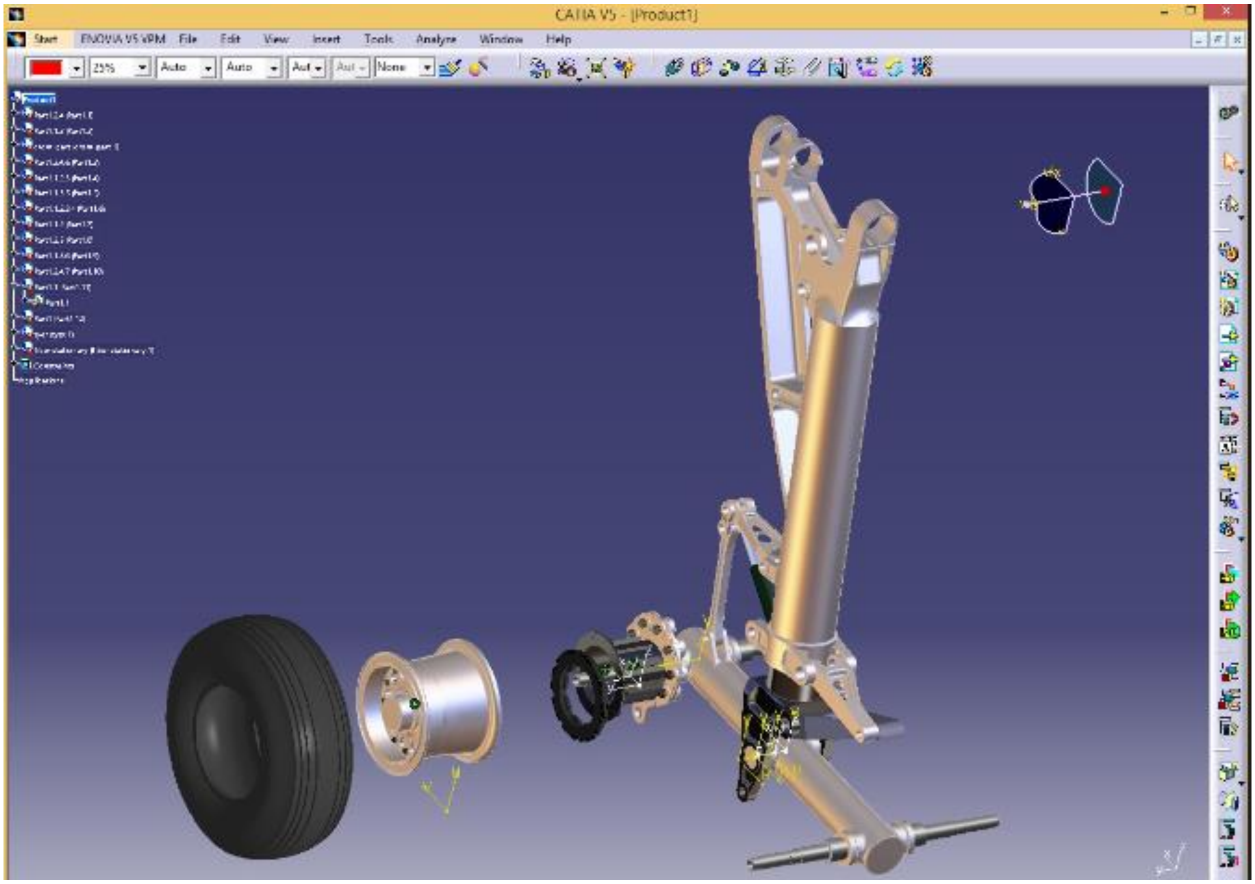
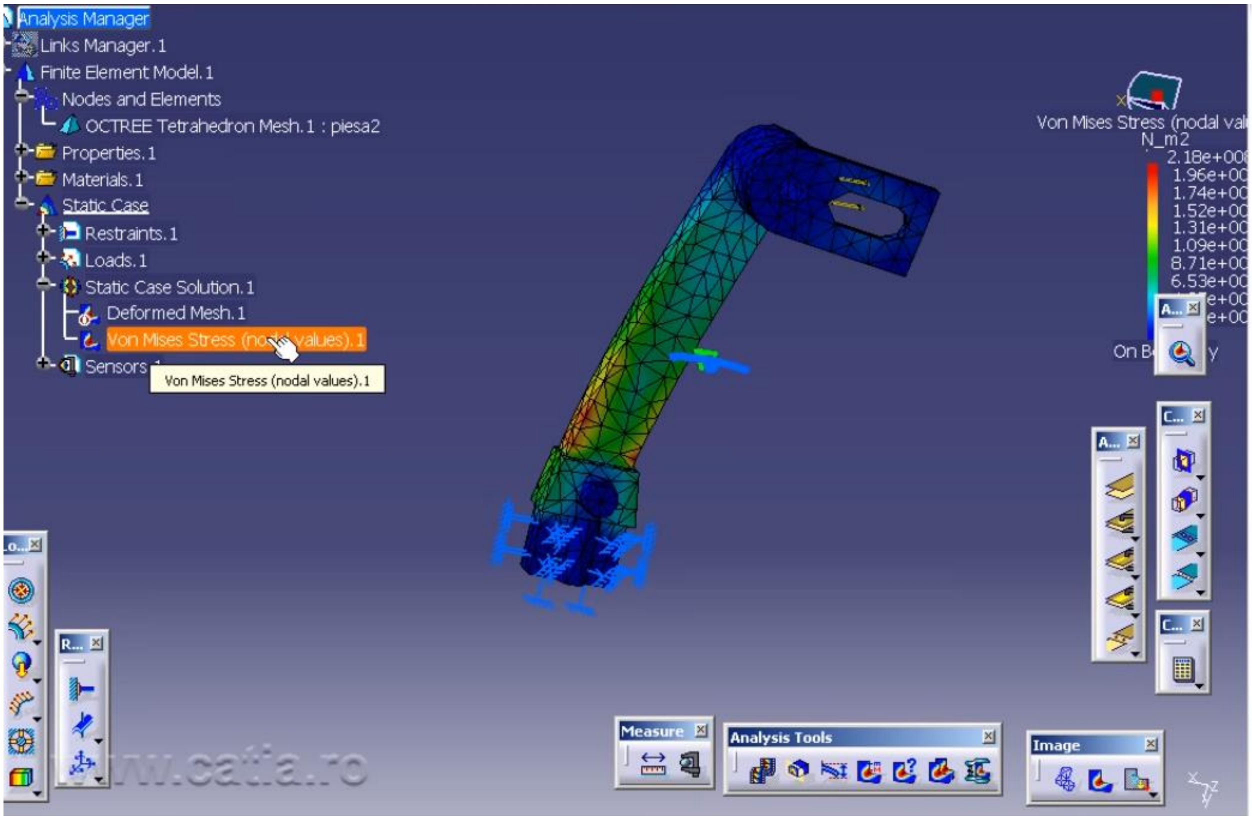


FIGURE 4: MODEL ANALYSIS

Material	Maximum stress (MPa)	Maximum Deformation (mm)	Factor of Safety
AA7075	797.2	1.974	0.11
AL STEEL	781	0.754	0.55
Ti6Al-4V	786.06	1.318	0.964
Ti6Al-6V-2Sn	791.45	1.3187	1.137
Ti10Al-2Fe-3V	781	0.754	1.236

TABLE 1: MODEL ANALYSIS BASED ON MATERIALS

Careful use of boundary conditions or loads is key to simulating real scenarios, which helps experts predict and improve the strength and usefulness of the arrival stuff. By obviously characterizing and managing by means of these limits, the review can give valuable data about how the appearance stuff acts when it is under utilitarian strain, which can assist with working on its arrangement for wellbeing and proficiency.



6. Conclusion

Managing stress tests is a key part of figuring out the overall health and trustworthiness of groups. This anticipatory assessment of anxiety feelings helps choose the right tools and make sure that the plan has the right mathematical parts. Through the examination of different materials, it has been recognized that Titanium 10V-2Fe-3Al shows the most positive properties concerning primary wellbeing. This particular composite shows the most noteworthy security factor among the materials considered, alongside the least qualities for greatest pressure improvement and avoidance under load.

Because of these discoveries, the decision of Titanium 10V-2Fe-3Al for the demonstrated landing gear is legitimate to upgrade the construction's versatility and unwavering quality. The prevalent presentation of this material in pressure examination demonstrates its capability to diminish the gamble of underlying disappointments altogether. By focusing on the utilization of Titanium 10V-2Fe-3Al, the plan guarantees that the arrival stuff can endure functional requests while keeping up with its respectability, subsequently adding to the general wellbeing and solidness of the airplane. This essential material determination is basic in accomplishing a powerful landing gear situation that satisfies thorough security guidelines.

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