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Design and FEA Simulation of Vehicle Suspension System by Using ANSYS

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Abstract: **The suspension system is a combination of tires, springs, shock absorbers, and connectors that connect the vehicle to its wheels, allowing the vehicle to travel reasonably well. The primary goal of this research was to mitigate the suspension system's overall weight. And improve the total strength of the vehicle suspension system by using ANSYS. Calculated the total deformation and equivalent stress at different loading conditions and check the durability of the system by using the FEA method. The deployment of FEA (finite element analysis) to analyses the fatigue life and stationary stress of a Vehicle Suspension System resulted in a flexible architecture that can be utilized in Vehicle Suspension Systems implementations. The current carbon alloy VSS can be lowered to a compact Vehicle Suspension Systems with better durable capabilities and good mechanical qualities, as well as emitting low carbon dioxide (CO2) benefits. On comparing T he titanium Ti-6Al-4V with Titanium Ti-13V-11Cr-3Al and cast iron, inside this analysis it is concluded that titanium Ti-6Al-4V outperforms than other two with regards to the material composition. Seeing as titanium Ti-6Al-4V has a greater yield stress on comparing to titanium Ti-13V-11Cr-3Al. The cast iron and titanium Ti-13V-11Cr-3Al have high densities while Titanium Ti-6Al-4V has low densities .**

Keywords: **VSS, Finite Element Methods, Suspension System, ANSYS.**

I. INTRODUCTION

The suspension system is a combination of tires, springs, shock absorbers and connectors that connect the vehicle to the wheels so that the vehicle can drive reasonably well. Suspension systems are essential for both travel management and continuity [1]. Currently, the suspension mechanism is one of the most important elements of the automotive system, which primarily determines the safety of the car and driving comfort. The suspension system transfers and controls the force and reaction (static and dynamic) between the vehicle and the ground [2]. The suspension system is a system of springs, fuses and links between the vehicle and its wheels. It is a process that physically separates the body from the wheel of the car.

The suspension system generally consists of three main components: a structure that maintains the weight of the vehicle and determines the geometry of the suspension; a spring that converts kinematic energy into potential energy; or vice versa and a damper, a mechanical device designed to dissipate kinetic energy [3]. Shock absorbers are hydraulic pump-type devices that help manage the impact and recoil motion of the vehicle's springs and suspension. The main function of the shock absorber is to ensure that the vehicle tire always remains in contact with the road surface, which provides the safest vehicle brake control and response. Fig 1 shows an example of a shock absorber used in the vehicle suspension.

The main task of the vehicle suspension is to reduce the vertical acceleration transmitted to the vehicle body (indirectly to passengers or loads) and thus ensure comfort directly in the lane.

Therefore, the objectives of the suspension system are: to prevent road collisions from being transmitted to the vehicle components; protect the resident from road vibrations; to maintain vehicle stability when pitching or rolling while driving [4].

Fig. 1 an illustration of a shock absorber used in automobiles

The growing demands in terms of overall vehicle dynamics and stability, as well as the rapid development of hybrid and electric cars, could contribute to the implementation of different controlled suspension systems and their integration into the overall control of passenger cars [1]. Several scientists have paid close attention to car suspension systems, including how to ensure the stability of suspension systems and how to improve the required suspension performance, ie ride comfort, handling and suspension deflection [4, 5]. So far, many vehicle suspension models have been offered. Suspension modification requires a thorough understanding of automotive suspension networks and vehicle dynamics. Keeping the wheel in contact with the road is essential for safe vehicle movement, as the total load of the car rests on the contact surfaces of the tires.

II. Literature Review

Swapnil S. Khode et al. [1] This study focuses on the finite element analysis of the lower triangle of the Mac-Pherson suspension system and its optimization under static load conditions. For the study, the existing design of the lower triangle is chosen from one of the light commercial vehicles. To determine the distribution of strains and stresses in the established design, FEA is executed. The available study aims to minimize the weight and costs of the triangle at the lower-side by maintaining the safety aspect inside the allowable limitations. Minimizing weight in a lower-side triangle is 17.5%.

Nikita Gawai et al. [2] This article explains how to optimize the swing arm suspension system in your car model. The vehicle model is generated in a virtual representation with the suspension system and the analysis was performed by ANSYS. The results of the theoretical values are validated with the values obtained from the finite element analysis.

Christianah O. Ijagbemi et al. [3] Study reveals that in gasoline, every gallon is burnt, 12.7 kg of carbon dioxide (CO_2) is emitted. The fuel consumption is almost linearly improves with a decrement in the weight of a car. Thus, minimizing weight of the vehicle results in lower fuel usage and lower carbon dioxide (CO_2) emissions, which in turn have an impact on global warming. Car productions are faced with incrementing stringent carbon dioxide (CO_2) emission norms. They are the result of solidity and longevity which, in the long term, reduce CO_2 emissions and it is not providing positive impact on the enviourment. This novel structure can be presented as a benchmark for the automotive industry.

SagarDarge et al. [4] The suspension system is one of the most important components of the vehicle, having a direct impact on the safety, performance, noise and style of the vehicle. The suspension in automobiles or vehicles is liable for comfortable driving and maintaining safety, as the quality of suspension supports the vehicle body and transfers all forces between the body and the road surface. Techniques for optimizing the structure under static load conditions are widely used in the automotive industry to improve lightweight construction and improve the performance of modern cars. To reduce stress and improve structural strength, Hyperworks adopts a topography optimization approach that defines a design area for a given part and creates a pattern of variable-shape stiffeners in that area to increase stiffness.

III. Objective

- Main objective of the study was reduce the total weight of the suspension system.
- Improve the total strength of the vehicle suspension system by using Ansys.
- Calculated the total deformation and equivalent stress at different loading conditions.
- calculated the factor of safety for VSS and check the durability of the system by using FEA method

IV. Methodology

A. FEA Analysis on Vehicle Suspension System.

Preparation of model:

A CAD model is prepared in Catia.

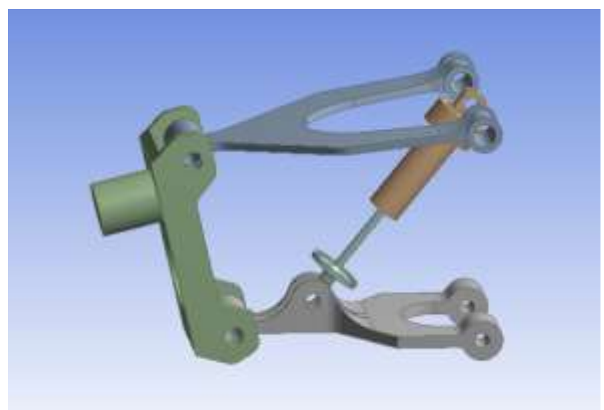


Fig. 2 Catia model

B. Steps of Working

Step 1: Gathering detailed data related to Vehicle Suspension System.

Step 2: A model completely depending on the parameters of the VSS for both cases, which are established in software CATIA V5R20

Step 3: Acquires model in Step 2 is investigated using ANSYS 19.

Step 4 : As a final point, the results obtained from ANSYS are compared.

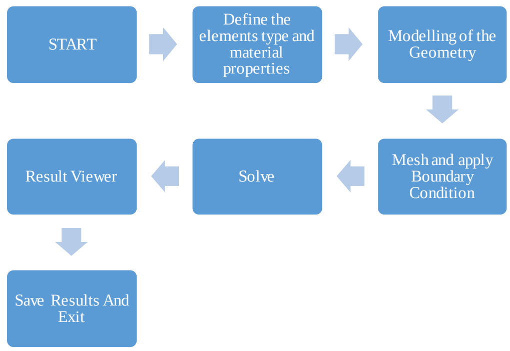


Fig. 3 Setup of working

C. *Finite elements analysis(FEA)*

Finite element analysis (FEA) is a subdivision of fluid mechanics that uses numerical research and data frameworks to examine and workout on solid architecture issues. The software ANSYS 19 was utilized for this project.

ANSYS Capabilities:

In the field of finite element model , The following processes are assigned with the assistance of ANSYS software:

- To create a computer working model, elements, and transfer CAD models of frameworks in a mechanism.
- Topology optimization improves the portfolio of structural components.
- Physical reactions including level of stress, temperature allocations, and electro-magnetic field scans should all be investigated.
- Design optimization is done to reduce production costs, Initially in the developing procedure,
- Prototype evaluation were performed in surroundings where this would be hard or not possible to do so or else (for e.g, bio-medical implementations).

D. *Steps Of ANSYS Analysis*

The ANSYS consists of GUI graphical user interface enables users to communicate with paperwork, program functions, orders, and relevant materials in an user-friendly way. Customers use a perceptive menu bar to browse via ANSYS program. A pair of both keyboard and mouse can be used or otherwise solely both can be used to insert information.

The various experimenting steps used by ANSYS are listed below.

1. PRE-PROCESSOR
   Preprocessor is primarily used to establish the model. Pre-processing stages:
   - Construct the model
   - Describe substances
   - Creating a component mesh
2. THE MODEL CONSTRUCTION

• Developing a strong model in Catia.

• Using a computer-aided design (CAD) mechanism to insert a model

Scenario-1 Constructing Architecture Model for 1st Scenario.

Fig. 4 CAD model arranged in Catia (base paper model)

SCENARIO-2 Constructing Architecture model for 2nd Scenario.

Fig. 5 Only one spring model arranged in Catia

SCENARIO-3 Constructing Architecture model for 3rd Scenario.

Fig. 6 Dual spring model arranged in Catia

3. Import Geometry in ANSYS For FEA Experimenting

Fig. 7 Import Geometry in Ansys

E. *Creating Mesh*

Figure 4.6 depicts the mesh generated in this project. The overall number of nodes obtained is 33685, and the overall number of attributes is 31745. It is fairly obvious from the mesh topography that the node and component numbers are somewhat seven in digits, indicating that the mesh is perfect.

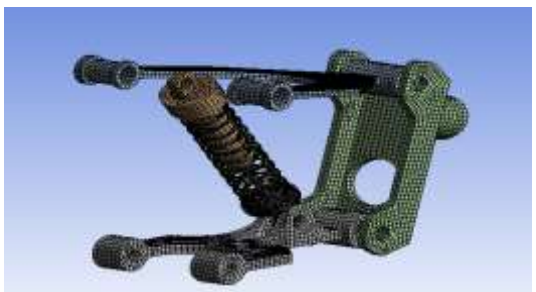


Fig. 8 Meshing: Over-all No. of Nodes: 61915& Over-all No. components: 160624

F. *Describing Characteristics of Substances*

- Cast iron characteristics

Properties	Value
Density (kg/m^3)	7800
Elastic modulus (N/m2)	2e11
Poisson ratio	0.32
Yield strength (N/m2)	2.48e8

Table 1.-Cast Iron Properties

- Titanium Ti-13V-11Cr-3Al

Properties	Values
Density (kg/m^3)	4820
Elastic modulus (N/m2)	9.9e10
Poisson ratio	0.30
Yield strength (N/m2)	8.3e8

Table 2:-Titanium Properties

- Titanium Ti-6Al-4V

Properties	Values
Density (kg/m^3)	4512
Elastic modulus (N/m2)	1.13e11
Poisson ratio	0.37
Yield strength (N/m2)	9.2e8

Table 3:-Titanium Properties

- Titanium Ti-6Al-4V

Properties	Values
Density (kg/m^3)	4512
Elastic modulus (N/m2)	1.13e11
Poisson ratio	0.37
Yield strength (N/m2)	9.2e8

Table 4-Titanium Properties

- Aluminum 7075-T6

Properties	Values
Density (kg/m^3)	2810
Elastic modulus (N/m2)	7.17e+10
Poisson ratio	0.33

Yield strength (N/m2)	5.03e+8

Table 4- Aluminum 7075-T6 Properties

- AMC225XE T4

Properties	Values
Density (kg/m^3)	2880
Elastic modulus (N/m2)	1.15e+10
Poisson ratio	0.30
Yield strength (N/m2)	4.8e+8

Table 5- AMC225XE T4Properties

Boundary Condition

1. Joints:- The amount of joints is determined by the previous boundary condition.

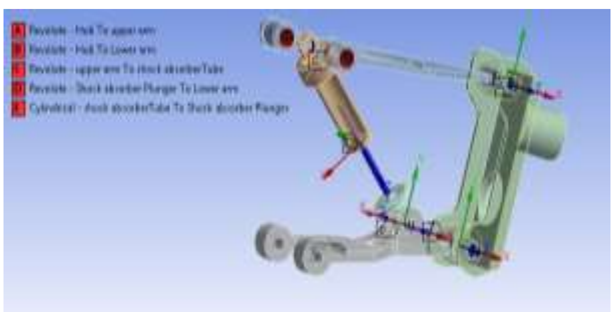


Fig. 9 Define Joints

2. Spring element:- Among the shock-absorbing system plunger and the shock-absorbing tube, describe the spring component.

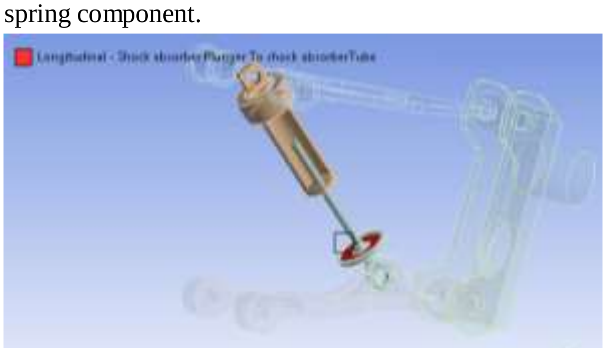


Fig. 10 Describe Spring component

3. Define Boundary conditions:-

Forces of around 14 kN/m2 and 2 kN/m2 were practiced to the Vehicle Suspension System in both axial and radial orientations. The radial force was ranged in between 14, 16, 18, 20, and 22 kN/m2 whereas the axial force stayed unchanged.

Boundary conditions	Radial Force(kN/m2)	Axial Force(2kN/m2)
1	14	2
2	16	2
3	18	2
4	20	2
5	22	2

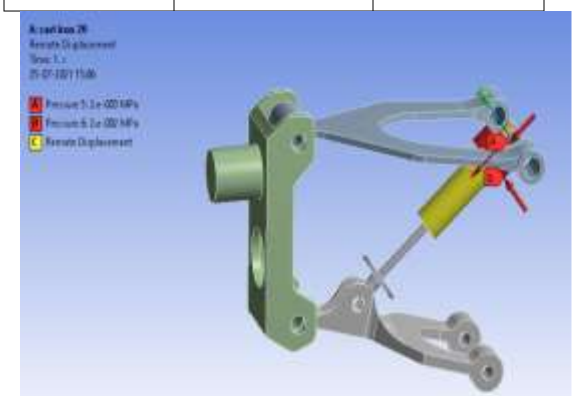


Fig. 11 Describe boundary conditions

4. Describe fixed support: - Using Vehicle Suspension System to implement rigid frame.

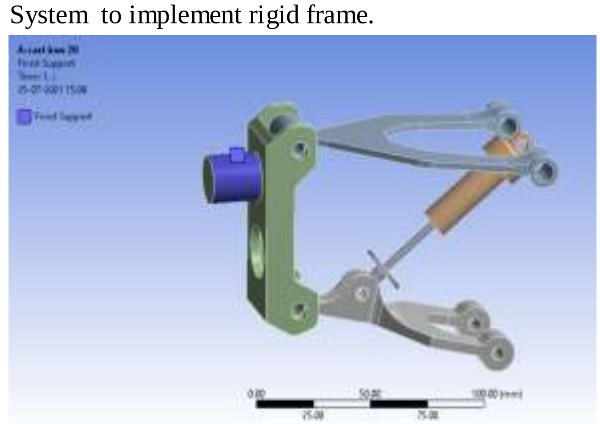


Fig. 12 Rigid Frame

5. Describe loading condition: - The vehicle suspension system (VSS) is subjected to axial and radial forces.

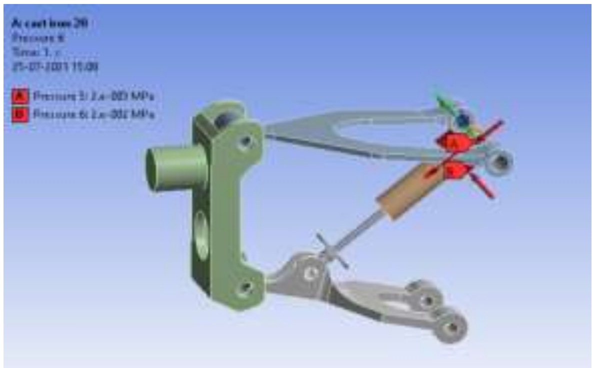


Fig. 13 Loading Situation

6. Describe loading situation: - Regulator the six degree of freedom of absorbing tube by practicing Remote dislocation.

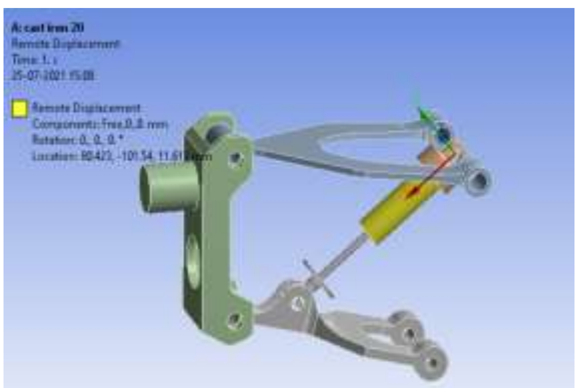


Fig. 14 Dislocation (Fixed translation in Y,Z direction)

7. Define material properties in ansys:-Define material properties in ansys.

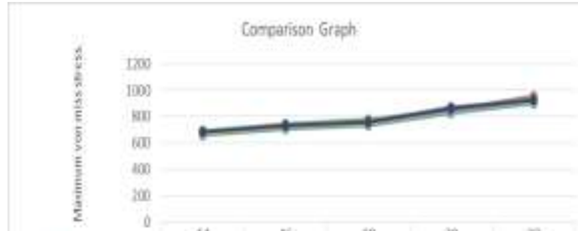
Properties of Outline Row 4: Aluminum 7075-T6

	A	B	C	D	E
1	Property	Value	Unit		
2	Material Field Variables	Table			
3	Density	2.81	g cm^-3		
4	Isotropic Elasticity				
5	Derive from	Young's Modulu...			
6	Young's Modulus	71700	MPa		
7	Poisson's Ratio	0.33			
8	Bulk Modulus	7.0294E+10	Pa		
9	Shear Modulus	2.6955E+10	Pa		

Fig. 15 Define material properties in ansys.

V. RESULTS

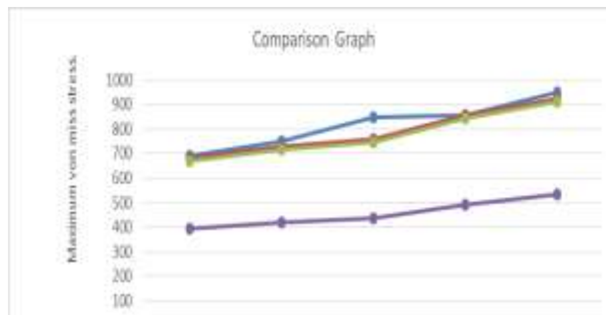
A. Finite Element Analysis Research on Vehicle Suspension System (VSS).



	14	16	18	20	22
BS CAST IRON	691	744	780	854	954
BS Titanium	681	740	770	855	950
CAST IRON	691.68	741.09	770	857.3	938.71
Titanium	681	730.65	759.88	869.55	925.49
Ti-6Al-4V	656.22	703.1	731.22	824	896.59
Aluminum 7075-T6	670.82	718.74	747.49	843.32	910.4
AMC225XE T4	681.93	730.64	759.87	857.29	925.48

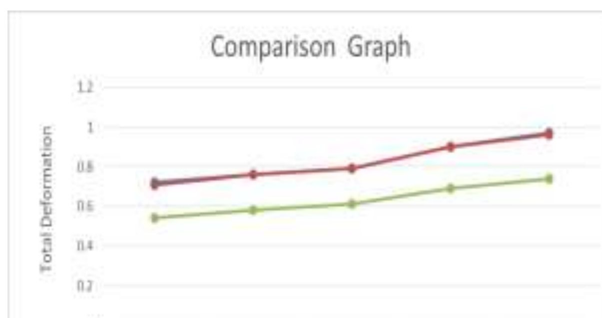
Graph 1 Highest von miss stress of the materials.

B. 2 Cast iron outcomes in scenario 1, 2, and 3.



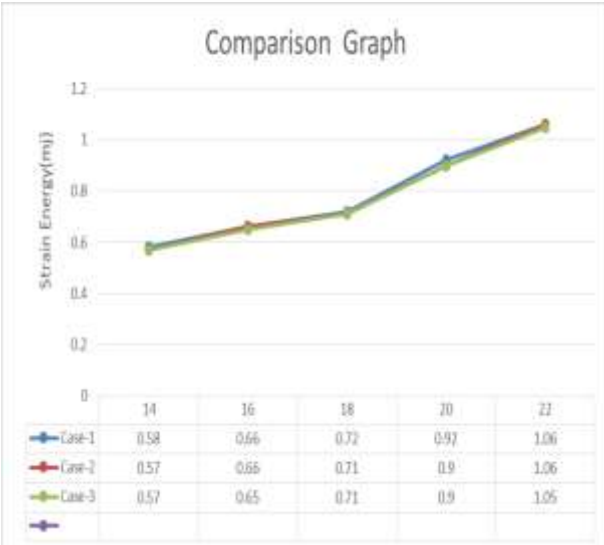
	14	16	18	20	22
BS CAST IRON	691	750	850	855	950
Case-1	681	730.65	759.88	857.3	925.49
Case-2	670.56	718.46	747.2	842.99	910.05
Case-3	392.44	420.47	437.29	493.35	532.59

Graph 2 Highest von miss stress of the substances.



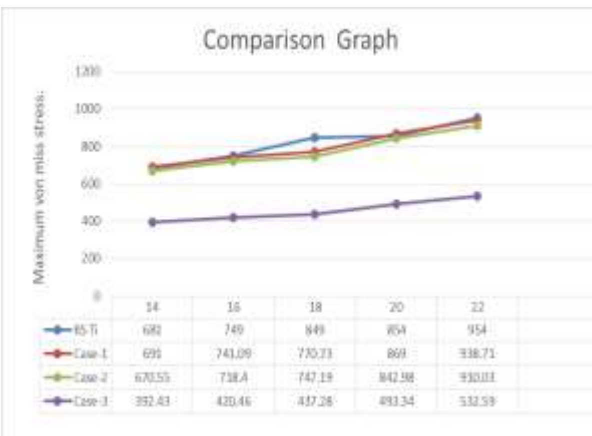
	14	16	18	20	22
Case-1	0.72	0.76	0.79	0.9	0.97
Case-2	0.71	0.76	0.79	0.9	0.96
Case-3	0.54	0.58	0.61	0.69	0.74

Graph 3 Over-all Deformation of the substances.

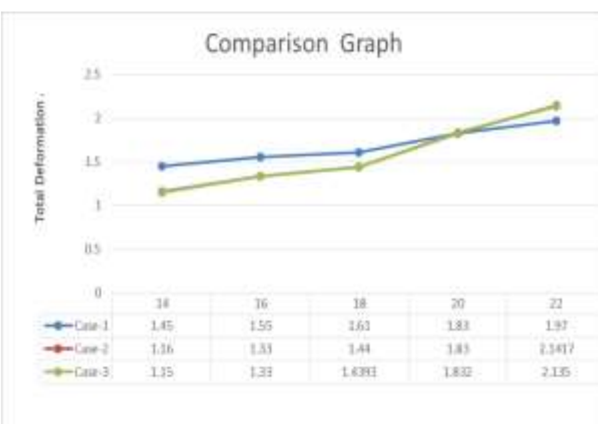


Graph 4 Strain Energy of the substances.

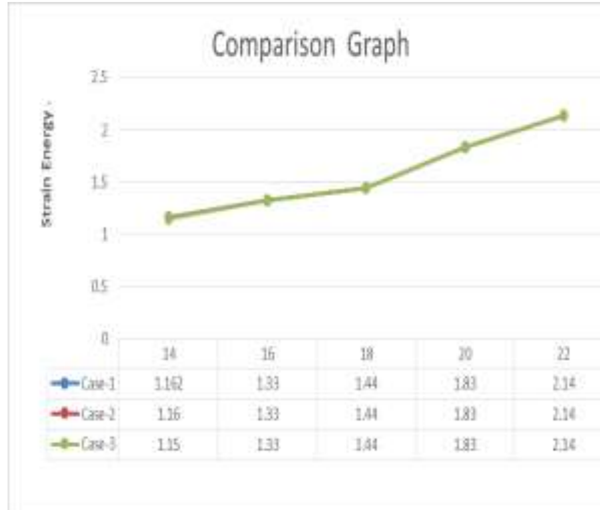
C. *Titanium result in scenario 1, 2, and 3.*



Graph 5 Highest von miss stress of the substances.

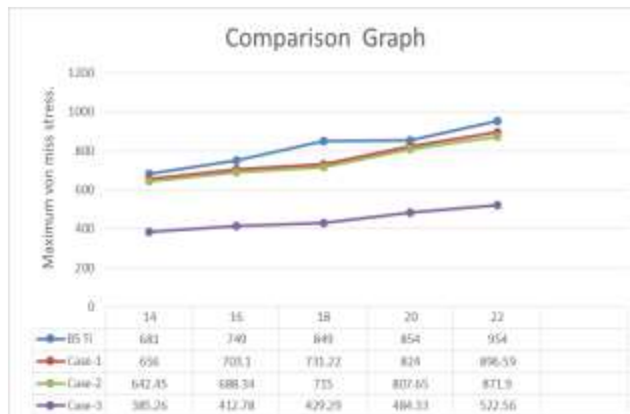


Graph 6 Over-all Deformation of the substances.

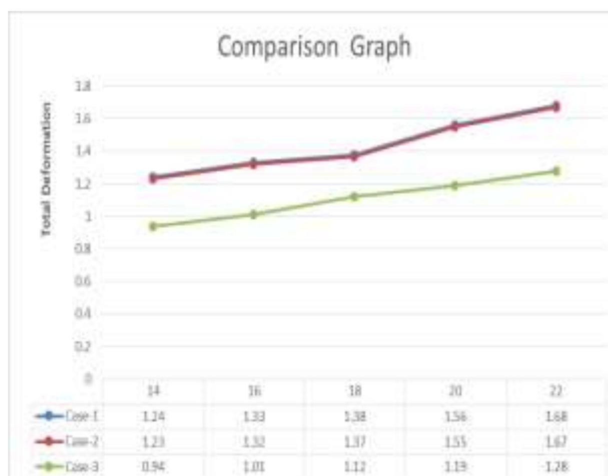


Graph 7 Strain Energy of the substances

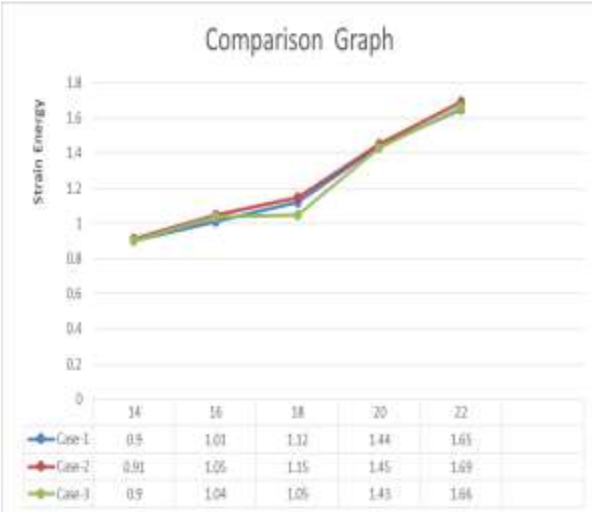
D. *Titanium Ti-6Al-4V outcome in scenario 1, 2, and 3.*



Graph 8 Maximum von miss stress of the materials.



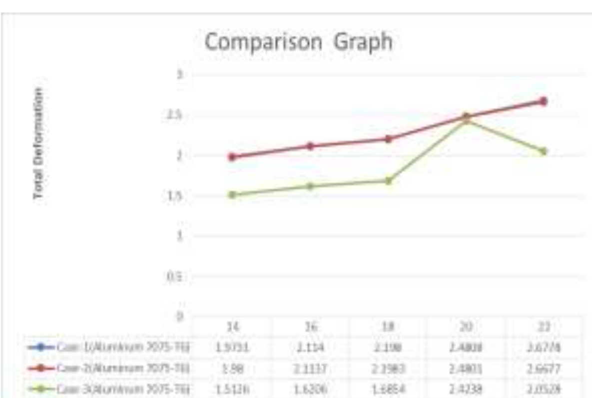
Graph 9 Total Deformation of the materials.



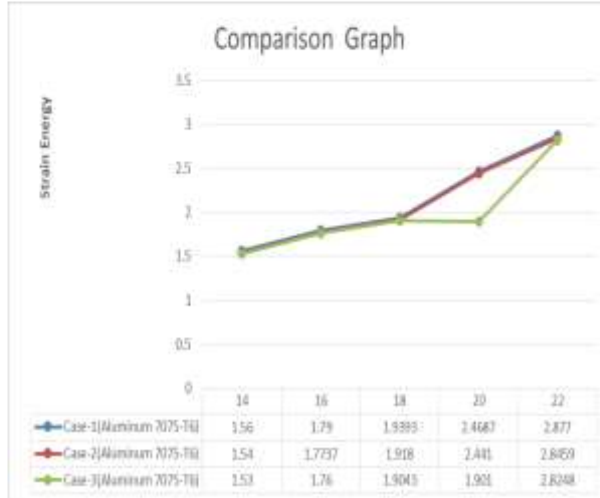
Graph 10 Strain Energy of the materials

E. Aluminum 7075-T6 result in case 1, 2, and 3.

Graph 11 Maximum von miss stress of the materials.

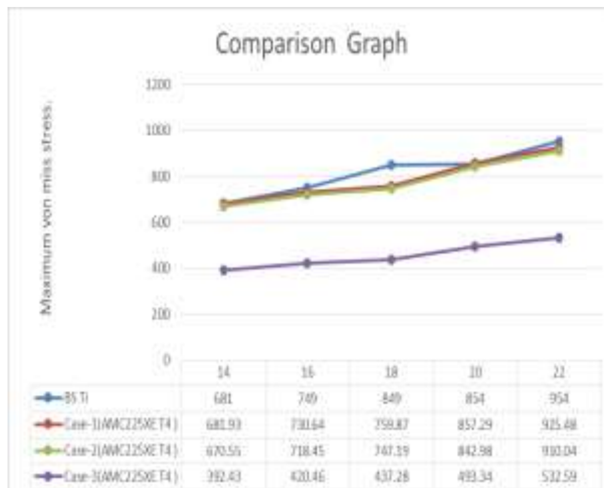


Graph 12 Total Deformation of the materials.

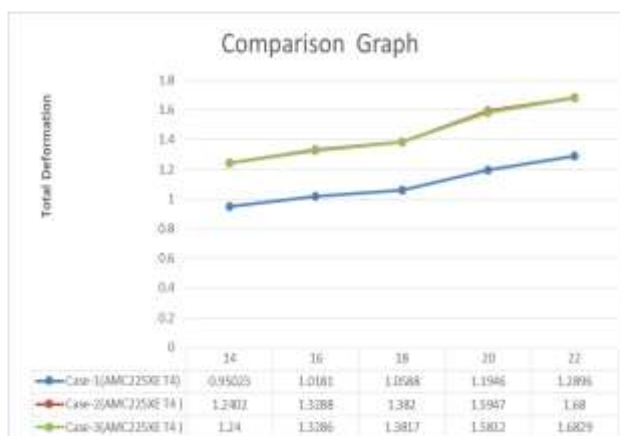


Graph 13 Strain Energy of the materials

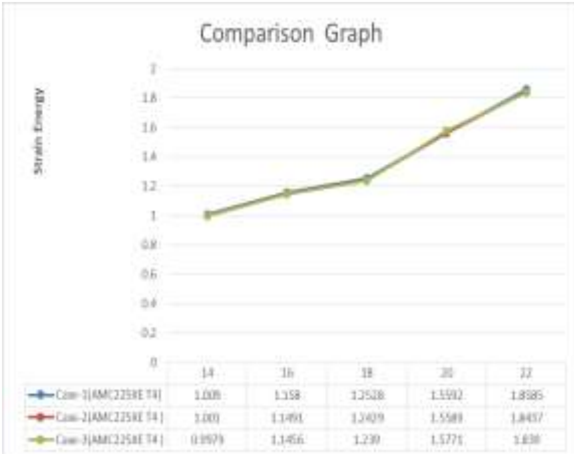
F. AMC225XE T4 1,2 and 3.



Graph 14 Maximum von miss stress of the materials.

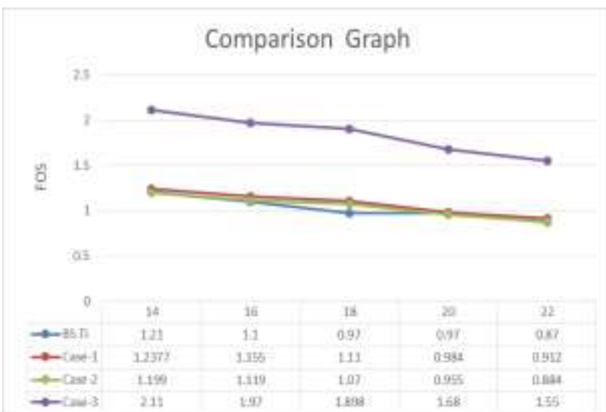


Graph 15 Total Deformation of the materials.



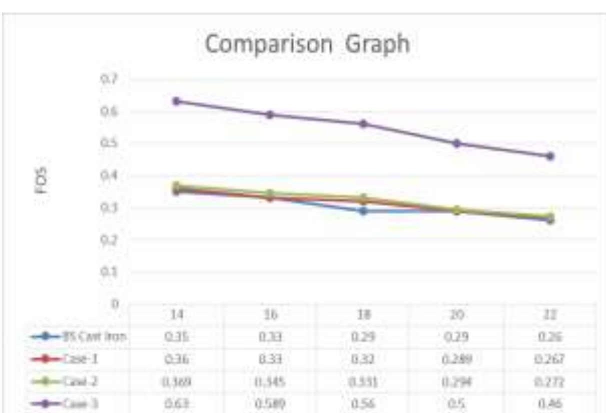
Graph 16 Strain Energy of the materials

G. Factor of safety of VSS (Titanium result in case 1, 2, and 3.)



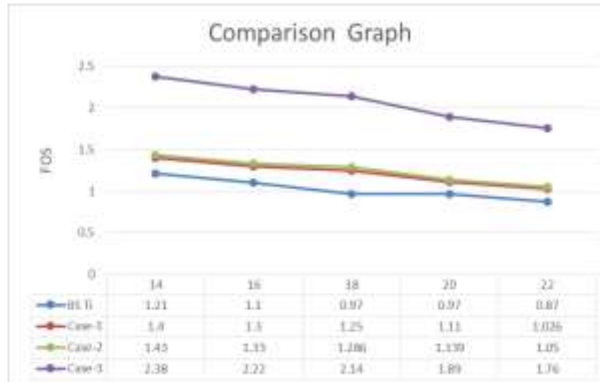
Graph 17 Comparison Graph (Factor of safety of VSS)

5.7 Factor of safety of VSS (Cast Iron result in case 1, 2, and 3.)

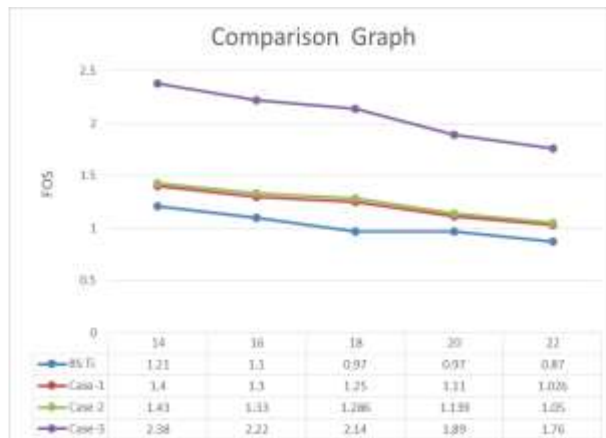


Graph 18 Comparison Graph (Factor of safety of VSS)

H. Factor of safety of VSS (Titanium Ti-6Al-4V result in case 1, 2, and 3.)

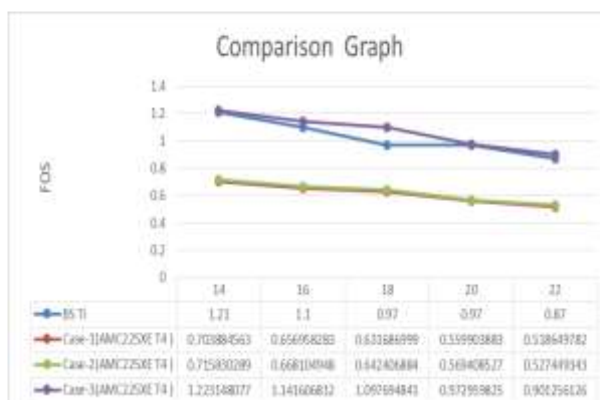


Graph 19 Comparison Graph (Factor of safety of VSS)



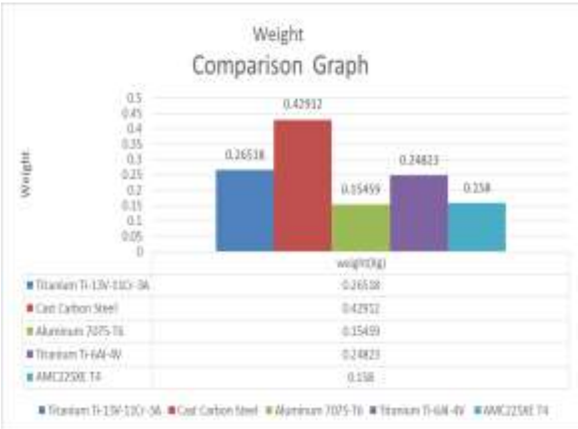
Graph 20 Comparison Graph (Factor of safety of VSS)

I. Factor of safety of VSS (AMC225XE T4 result in case 1, 2, and 3.)



Graph 21 Comparison Graph (Factor of safety of VSS)

J. Weight Comparison Graph.



Graph 22 Comparison Graph

VI. CONCLUSION

The deployment of FEA (finite element analysis) to analyse the fatigue life and stationary stress of a Vehicle Suspension System resulted in a flexible design that can be used in VSS implementations. This paper introduces a fatigue assessment for Vehicle Suspension System, and it can be concluded that depending on the simulation outcomes that:

• The current VSS, which is comprised of alloys of carbon (C), can be lowered to a lighter in weight Vehicle Suspension System with better duration capability and mechanical ability, as well as a reduced Carbon dioxide emission benefit.

- At the various loads regarded, the FOS for alloys of carbon (C) at an appropriate yield stress below VMS valuation is nearly 0.50;
- In the third case, Titanium Ti-6Al-4V Solution Allowed to treat has a FOS of nearly 2.38. Because of the dual spring, the overall strength of Titanium is elevated. In case 3, the value of equilavant stress decreases, and the overall safety factor rises to 2.38.
- •In scenario three, the highest von Mises stress decreases while the FOS rises. In the third scenario, the safety factor is highest 2.38 and least 1.76.
- However, the value of FOS 0.63 at 14kN/m3 radial force in the scenario of cast iron a t 22kN/m2, it's 0.46.
- Aluminum 7075-T6 has a lower overall weight than another substance. In the third scenario, the aluminum's safety margin is 1.29. Aluminum 7075-T6 has a safety factor of more than one. As a result, aluminum has the capacity to endure greater loads.

The analysis's final conclusion The weight ofTi-13V-11Cr-3Al is higher on comparing with AMC225XE T4 , and the factor of safety is allowable in Scenario-3. and the aluminum alloy AMC255XE is cheap on comparing with Ti-13V-11Cr-3Al.

VII. FUTURE SCOPE

• The current research is based on static load situations.

• In the coming years, vibrant situations will be analysed as well.

• The dynamic scenario research will enable the precision of the findings.

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