Modelling And Structural Analysis Of Two Wheeler Chasis Frame

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Abstract: Lot of research was done and numbers of papers were published on design and analysis of chassis previously, but most of them are restricted to validating and optimizing the design for static loads only. In this present project design and analysis of two wheeler frame is done using four materials alloy steel, aluminum alloy A360, magnesium and carbon fiber reinforced polymer to verify the best material for frame.This project extended to shock analysis by considering 3 bumps per second with the peak acceleration as per the standard road tests. Software used in this work is NX-CAD for modeling and ANSYS for analysis. Manufacturers have been concentrating their interests on lightweight bodies. However, fabrication of lightweight body is limited by constraints such as weight, stiffness. Weight reduction can be achieved primarily by introduction of better material, design optimization and better manufacturing process. Frames used in mechanical design, which are still design on rule of thumb, are one of the potential areas for design optimization for better stiffness. Frame specially two wheeler frame due to its geometrical construction, assemblies and complex loading conditions cannot be analysis by theoretical model and hence need a power full numerical approach for analysis. The two-wheeler chassis consists of the frame, suspension, wheels and brakes. The frame serves as a skeleton upon which parts like gearbox and engine are mounted. It can be made of steel, aluminum or an alloy. It is essential that the frame should not buckle on uneven road surfaces and that any distortions which may occur should not be transmitted to the body. The frame must therefore be torsion resistant.

Keywords: Static analysis, Modeling analysis, Shock analysis.

I. Introduction

Due to the globalization of the market, the manufacturers are facing a lot of problems for surviving. Especially for the automotive industry, they have some critical challenges like making a light weight bodies, more stiffness etc. In the earlier stages, most of the manufacturers tested the hardware directly, but its was a difficult and typical testing, which take a lot of time and money also. To escape from such type of conditions, they are starving for any technique by which they can analyze the frame and its strength and stiffness simultaneously. Due to this requirement, they are allured to some software. Among all the analysis software, CAE is the most reliable software which fulfills the need of the manufacturers of automotive frames. In this software, they can simulate the original frame and they can analyze it very easily. They can visualize the whole simulation process. Even, they can optimize their process. The aim of this paper is to show the analysis of a two-wheeler frame through CAE. In this paper, the whole problem along-with their constraint has been shown.

II. Literature review

A Review on Design and Analysis of Two-wheeler Chassis by GauravVasantrao Bhunte1 and Dr. Tushar R. Deshmukh.In this paper an exertion is made to survey the examinations that have been made on the distinctive investigation systems of car outlines. That examination might be, static investigation or dynamic examination. Various explanatory and exploratory strategies are accessible for the investigation of the vehicle outlines. Assurance of the distinctive investigation around various conditions in a vehicle outlines has been accounted for in writing. An endeavor has been made in the article to show an outline of different systems created for the examination of car casings and aftereffects of that investigation because of which additionally consider on the undercarriage will turn out to be simple".Basic investigation of two-wheeler suspension outline by CH.Neeraja, C.R.Sireesha and D.Jawaharlal. In this task "The two-wheeler body comprises of the edge, suspension, haggles. The case really sets the general style of the two-wheeler. Car case is the fundamental carriage frameworks of a vehicle. The edge fills in as a skeleton whereupon parts like gearbox and motor are mounted. It can be made of steel, aluminum or a combination. It is fundamental that the edge ought not clasp on uneven street surfaces and that any mutilations which may happen ought not be transmitted to the body. The edge should subsequently be torsion safe. The point of the undertaking is to demonstrate an edge utilizing 3D displaying programming Pro/Engineer. To approve the quality of an edge, Structural investigation is finished by applying the wheel powers. In this investigation extreme pressure constrain for the model is resolved. Investigation is improved the situation outline utilizing four materials amalgam steel, aluminum composite A360, magnesium and carbon fiber fortified polymer to confirm the best material for outline. Show investigation is likewise done to decide distinctive mode shapes for number of modes. Examination is done in ANSYS programming".

III. Problems and methodology

In this present task plan and investigation of two-wheeler case is improved the situation outline utilizing four materials composite steel, aluminum compound A360, magnesium and carbon fiber strengthened polymer to confirm the best material for outline. In

the present work, the measurements of a current vehicle frame are taken for displaying and examination of a two-wheeler vehicle case. Modular examination is performed to discover normal frequencies. From the investigation comes about anxieties and avoidances are plotted. This task stretched out to stun examination by considering 3 knocks for each second with the pinnacle increasing speed according to the standard street tests. Programming utilized as a part of this work is NX-CAD for displaying and ANSYS for investigation.

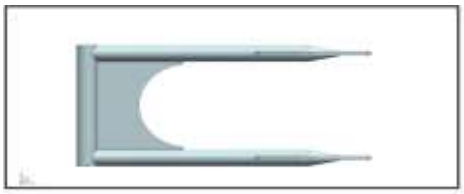
Methodology followed in this project:

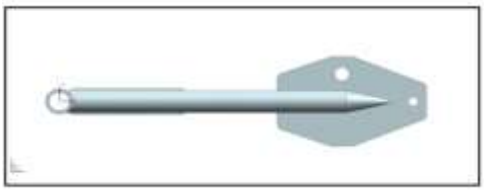
- Based on previous papers, 3d model of chassis assembly is generated by using NX-CAD software.
- 3d model of chassis assembly is converted into Parasolid file.
- The Parasolid file is imported to ANSYS software to perform analysis on chassis assembly.
- Static analysis is performed on chassis assembly for static load (i.e. total weight of vehicle) to check the deflections and stresses for different materials (alloy steel, aluminum alloy A360, magnesium and carbon fiber reinforced polymer).

IV.3D MODELING OF TWO-WHEELER FRAME CHASSIS

3D modeling of two-wheeler chassis was modeled using NX-CAD software based on previous papers

4.1.1 Top view of two-wheeler frame chassis: **4.1.2 Front view of two-wheeler frame chassis:**





V. FINITE ELEMENT ANALYSIS OF TWO-WHEELER FRAME CHASSIS

5.1 STRUCTURAL ANALYSIS OF TWO-WHEELER FRAME CHASSIS FOR ALLOY STEEL:

Limited Element Modeling (FEM) and Finite Element Analysis (FEA) are two most prevalent mechanical designing applications offered by existing CAE frameworks. This is credited to the way that the FEM is maybe the most mainstream numerical strategy for taking care of designing issues. The strategy is sufficiently general to deal with any mind boggling state of geometry (issue space), any material properties, any limit conditions and any stacking conditions. The all inclusive statement of the FEM fits the examination necessities of the present complex building frameworks and outlines where shut shape arrangements are overseeing harmony conditions are not accessible. Likewise it is an effective outline instrument by which planners can perform parametric plan contemplating different cases (diverse shapes, material burdens and so on.) examining them and picking the ideal plan**.**

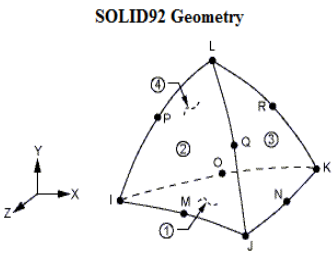
5.2 FINITE ELEMENT METHOD

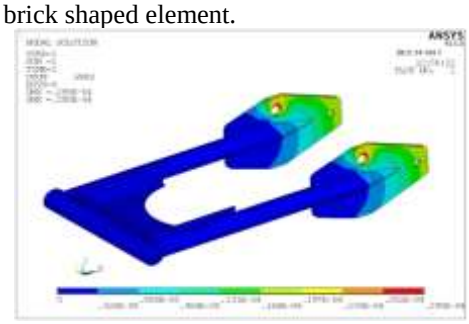
The FEM is numerical examination system for acquiring surmised answers for wide assortment of building issues. The technique began in the aeronautic trade as an apparatus to contemplate worries in confused airframe structures. It became out of what was known as the framework examination technique utilized as a part of airplane outline. The technique has picked up prevalence among the two analysts and specialists and after such huge numbers of advancements codes are produced for wide assortment of issues.

5.3.1 STATIC ANALYSIS OF TWO-WHEELER FRAME CHASSIS:

Material properties of alloy steel:

- Young modulus(E) = **200GPa**
- Density (ρ) = **7850 kg/m3**
- Yield strength = **275MPa**
- Poison's ratio **= 0.25**
- **10 NODE SOLID92:**
- SOLID92 has quadratic displacement behavior and is well suited to model irregular meshes (such as produced from various CAD/CAM systems). See SOLID95 for a 20-node brick shaped element.





Natural frequency:

Natural frequency is the frequency at which a system naturally vibrates once it has been set into motion. In other words, natural frequency is the number of times a system will oscillate (move back and forth) between its original position and its displaced position, if there is no outside interference.

The natural frequency is calculated from the formula given below. The natural frequencies depend on stiffness of the geometry and mass of the material.

Resonance:

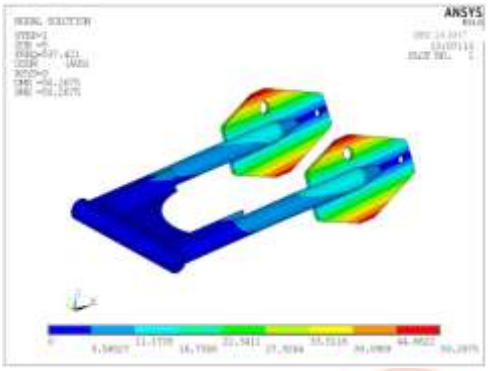
In physics, resonance is the tendency of a system to oscillate with greater amplitude at some frequencies than at others. Frequencies at which the response amplitude is a relative maximum are known as the system's resonant frequencies, or resonance frequencies. At these frequencies, even small periodic driving forces can produce large amplitude oscillations, because the system stores vibrationenergy.

Modal analysis:

Modal analysis was carried out on two-wheeler frame chassis to determine the first 5 natural frequencies and mode shapes of a structure. From the modal analysis, a total of 5 natural frequencies are observed.

Boundary conditions: The boundary conditions applied for the modal analysis are shown below

- Inner tube areas of t d he frame are constrainein all DOF.

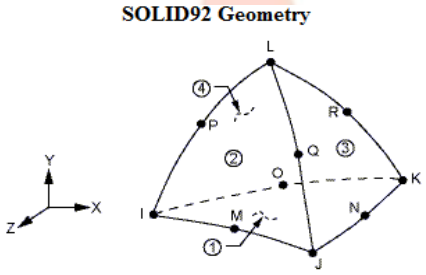


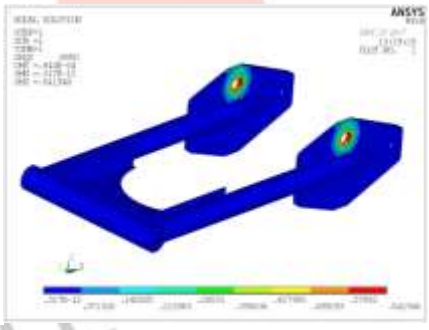
MODE	FREQUENCY
1	84.68
2	85.37
3	104.2
4	105.6
5	537.4

STRUCTURAL ANALYSIS OF TWO-WHEELER FRAME CHASSIS FOR ALUMINIUM ALLOY:

Material properties of Aluminium alloy:

- Young modulus(E) = **70GPa**
- Density (ρ) = **2800 kg/m3**
- Yield strength = **240MPa**
- . Poison's ratio **= 0.25**





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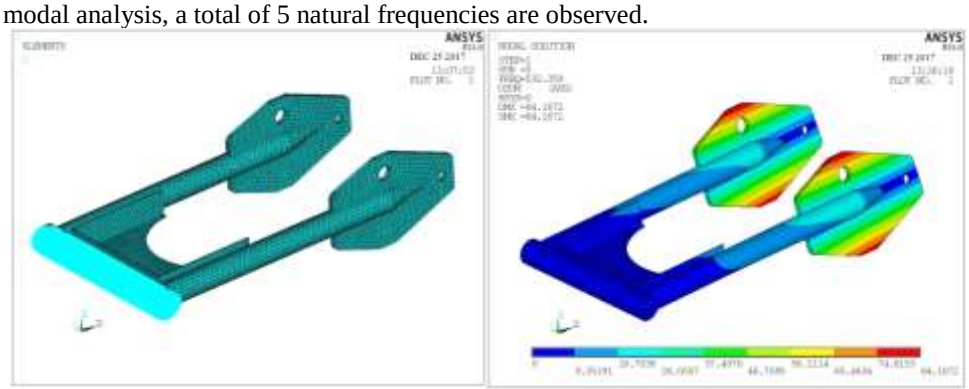
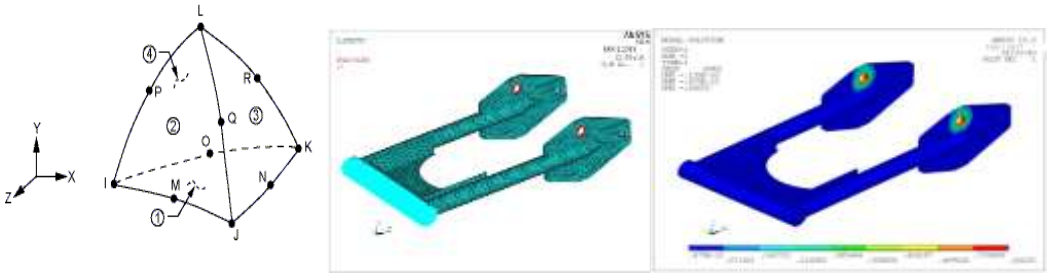


STRUCTURAL ANALYSIS OF TWO-WHEELER FRAME CHASSIS FOR MAGNESIUM MATERIAL:

Material properties of Magnesium material:

- Young modulus(E) = **45GPa**
- Density (ρ) = **1850 kg/m3**
- Yield strength = **180MPa**

- Poison's ratio = **0.1**



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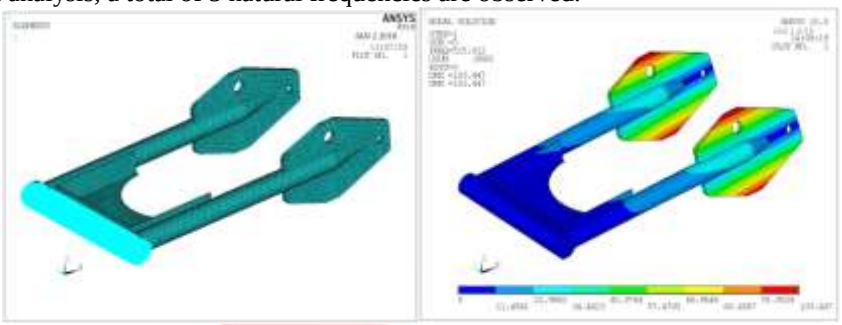

STRUCTURAL ANALYSIS OF TWO-WHEELER FRAME CHASSIS FOR CARBON EPOXY MATERIAL:

Material properties of Carbon epoxy material:

- Young modulus(E1) = **134GPa**
- Young modulus(E2) = (E3) = **7GPa**
- Shear modulus = **5.8GPa**
- Density (ρ) = **1600 kg/m^3**
- S_{12} = **880MPa**
- S_{23} = **60MPa**
- S_{13} = **97MPa**
- Poison's ratio = **0.3**

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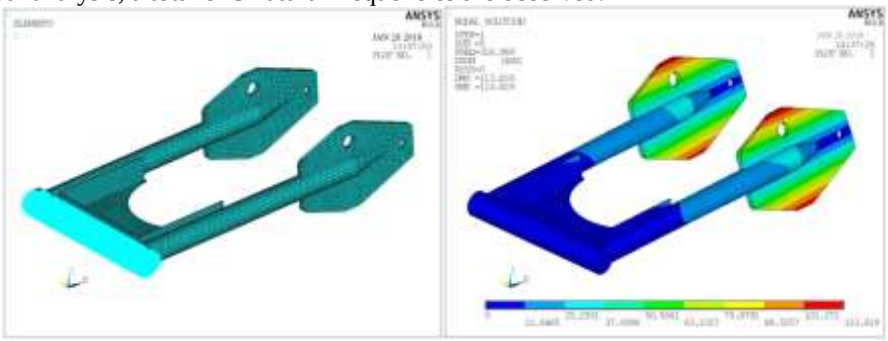
Modal analysis was carried out on two-wheeler frame chassis to determine the first 5 natural frequencies and mode shapes of a structure. From the modal analysis, a total of 5 natural frequencies are observed.



According to above analysis results of two-wheeler chassis frame for different materials, carbon epoxy material has high displacement compare to other materials but comparing other aspects like stresses and factor of safety, carbon epoxy material is better . By considering modal analysis results, carbon epoxy material high fundamental frequency. By taking all the aspects into consideration, carbon epoxy material is the best material for two-wheeler chaassis frame. Further, shock analysis is carried out on two-wheeler chassis frame for carbon epoxy material.

VI.SHOCK ANALYSIS OF TWO-WHEELER FRAME CHASSIS

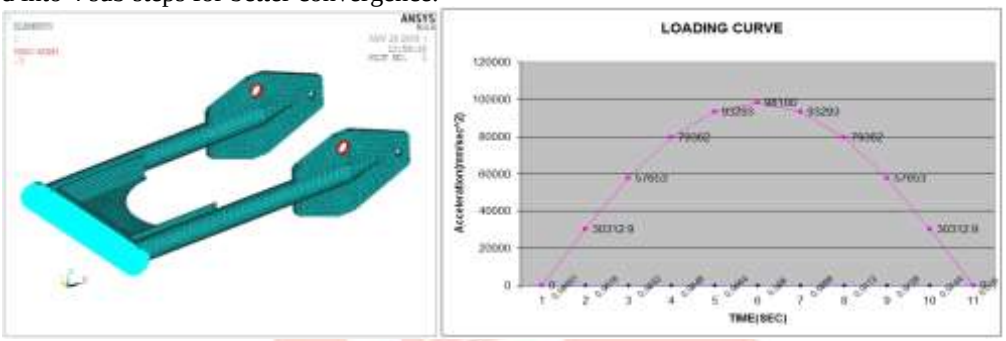
Transient examination is a strategy to decide the reaction of a structure to subjective time-fluctuating burdens, for example, a blast. Transient dynamic investigation is utilized as a part of the outline of: Structures subjected to stun loads, for example, vehicle entryways and guards, building casings, and suspension frameworks. Structures subjected to time-shifting burdens, for example, spans, earth moving gear, and other machine parts. Family and office hardware subjected to "knocks and wounds, for example, mobile phones, PCs, vacuum cleaners.

- Equation of motion for a transient dynamic analysis is the same as the general equation of motion.
- This is the most general form of dynamic analysis. Loading may be any arbitrary function of time.
- Depending on the method of solution, ANSYS allows all types of nonlinearities to be included in a transient dynamic analysis - large deformation, contact, plasticity, etc.

The two-wheeler frame chassis is subjected to 3 bumps per sec with the peak acceleration as per the standards is given in table. Each bump can be treated as a half sine curve with a time period of as per **table**

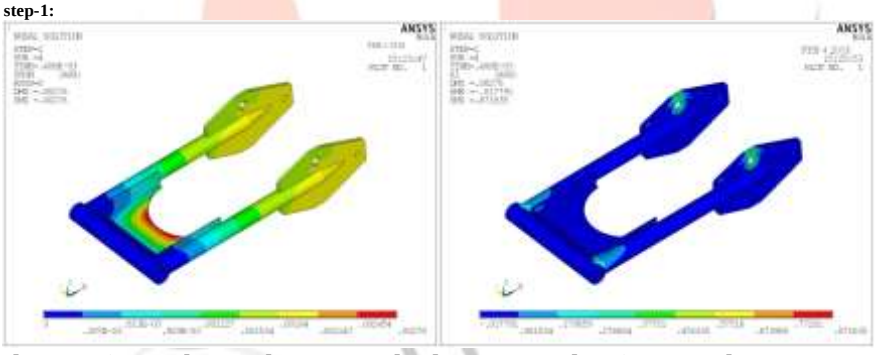
Peak Acceleration(m/sec^2)	Pulse Duration(ms)	Number of Bumps	Application
100	16	1	General Ruggedness test.

The below analysis is carried out for a single bump. All the acceleration inputs are converted into ‘g’ values and the input loads (in terms of acceleration) are calculated. The whole loading curve is divided into 10 load steps (time period=1.6msec) and each load step is divided into 4 sub steps for better convergence.



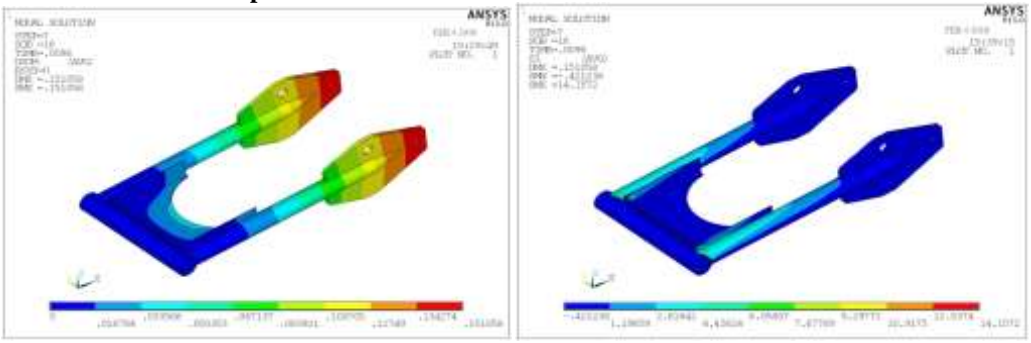
Results:

Displacements and Stresses at load step-1:



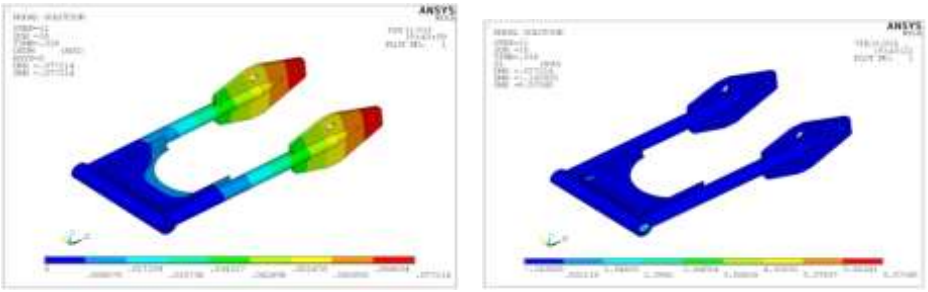
Total Displacement and Von Misses Observed on Two-wheeler Frame Chassis at Load Step-1

Displacements and Stresses at load step-2:



Total Displacement and Von Misses Observed on Two-wheeler Frame Chassis at Load Step-2

Displacements and Stresses at load step-3:



Total Displacement and Von Misses Observed on Two-wheeler Frame Chassis at Load Step-3

VII. RESULTS

Two-wheeler chassis frame was modelled in NX-CAD software. Two-wheeler chassis frame was analyzed for static analysis and modal analysis using different materials. Consequences of static and modular investigation for various materials are:

1. BasicANALYSIS OF TWO-WHEELER FRAME CHASSIS FOR STEEL ALLOY MATERIAL:

From the static analysis, the maximum displacement of 0.29e-4mm was observed on two-wheeler frame chassis. The maximum Von Misses stress of 0.64MPa is observed on the chassis two-wheeler frame. The yield strength of the material is 275MPa. The Von Mises stress is less than the yield stress of the material.

From the modal analysis, the total weight of the two-wheeler frame chassis is 0.3e-2Tons.

2. Basic ANALYSIS OF TWO-WHEELER FRAME CHASSIS FOR ALUMINIUM ALLOY MATERIAL:

From the static analysis, the maximum displacement of 0.8e-4mm was observed on two-wheeler frame chassis. The maximum Von Misses stress of 0.64MPa is observed on the chassis two-wheeler frame. The yield strength of the material is 240MPa. The Von Mises stress is less than the yield stress of the material.

From the modal analysis, the total weight of the two-wheeler frame chassis is 0.13e-2 Tons.

3. Basic ANALYSIS OF TWO-WHEELER FRAME CHASSIS FOR MAGNESIUM MATERIAL:

From the static analysis, the maximum displacement of 0.13E-3mm was observed on two-wheeler frame chassis. The maximum Von Misses stress of 0.64MPa is observed on the chassis two-wheeler frame. The yield strength of the material is 180MPa. The Von Mises stress is less than the yield stress of the material.

From the modal analysis, the total weight of the two-wheeler frame chassis is 0.86E-3Tons.

4. Basic ANALYSIS OF TWO-WHEELER FRAME CHASSIS FOR CARBON EPOXY MATERIAL:

From the static analysis, the maximum displacement of 0.61e-3mm was observed on two-wheeler frame chassis. The maximum 1^{st}, 2^{nd} and 3^{rd} principal stresses of 0.47MPa, 0.03MPa and 0.003MPa are observed on the chassis two-wheeler frame. The 1^{st}, 2^{nd} and 3^{rd} principal stresses of the material are 880MPa, 60MPa and 97MPa. The 1^{st}, 2^{nd} and 3^{rd} principal stresses observed are less than the 1^{st}, 2^{nd} and 3^{rd} principal stresses of the material. So, design of two-wheeler frame chassis is safe for static loads.From the modal analysis,the total weight of the two-wheeler frame chassis is 0.74e-3Tons.

CONCLUSION

Two-wheeler chassis frame was modelled using NX-CAD software. The two-wheeler chassis frame model was imported to ANSYS software to perform structural analysis (i.e. static and modal analysis). The analysis was done on the two-wheeler chassis frame for different materials (steel alloy, aluminium alloy, magnesium alloy and carbon epoxy material). From the static analysis, steel alloy has displacement value compare to other materials, but comparing to stresses and factor of safety, carbon epoxy material was better. From the modal analysis, fundamental frequency of carbon epoxy material was high compare to other materials. By considering results of static and modal analysis, it was concluded that the carbon epoxy material was best material compare to other materials. Further, shock analysis was done on the two-wheeler chassis frame for carbon epoxy material. The stresses for all load steps were less than the stresses of the material. By considering all results, Finally, it was conclued that the two-wheeler chassis frame was safe for static and shock loads.

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