IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
SITES
Smart And Innovative Technologies In Engineering And Sciences
Gyan Ganga College of Technology
Vol. 3, Special Issue 4, November 2016

FEA Analysis for Designed Chassis

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Abstract: Research work describes analysis of designed chassis frame for customized vehicle. Practically the strength of the chassis depends on the material used for manufacturing. Analyzing the effect of the changing the material of manufacturing of chassis is done. The deformation of members, stress developed in the chassis and strain in chassis is taken as the major effect in this research. The research is done by taking in account most widely used materials now a day's i.e. Steel, Magnesium alloy and Aluminium alloy.

Keywords: Finite element analysis (FEA), Chassis, Aluminium alloy, Magnesium alloy.

I. INTRODUCTION

Automotive chassis is a skeletal frame on which various mechanical parts like engine, tires, axle assemblies, brakes, steering etc. are bolted. The chassis is most important part of an automobile. It is the part that gives strength and stability to the vehicle under different conditions. Automobile frames provide strength and flexibility to the automobile. It is the backbone of any automobile. Automotive frames are basically manufactured from steel. It provides strength needed for supporting vehicular components and payload placed upon it. It is usually made of a steel frame, which holds the body and motor of an automotive vehicle. At the time of manufacturing, the body of a vehicle is flexibly molded according to the structure of chassis.

A. Ladder Frame
So named for its resemblance to a ladder, the ladder frame is one of the simplest and oldest of all designs. It consists of two symmetrical beams, rails or channels running the length of the vehicle and several transverse cross members connecting them. It is now seen mainly on trucks. It has poor resistance to torsion or warping if simple, perpendicular cross members are used.

B. Backbone tube
A backbone chassis is a type of automobile construction chassis that is similar to the body-on-frame design. Instead of a two-dimensional ladder type structure, it consists of a strong tubular backbone (usually rectangular in cross section) that connects the front and rear suspension attachment areas. A body is then placed on this structure.

C. Monocoque
Monocoque is a structural approach whereby loads are supported through an object's external skin, similar to an egg shell. The technique may also be called structural skin. The word monocoque is a French term for "single shell". Monocoque Chassis is a one-piece structure that prescribes the overall shape of a vehicle. This type of automotive chassis is manufactured by welding floor pan and other pieces together. Since monocoque chassis is cost effective and suitable for robotized production, most of the vehicles today make use of steel plated monocoque chassis.

II. THEORY

Finite element Analysis (FEA):- It is the numerical technique for finding approximate solution to boundary value problem for partial differential equations. It subdivides a large problem into smaller, simpler parts that are called finite elements. FEA uses variation methods from the calculus of variations to approximate a solution by minimizing an associated error function. It is useful for problems with complicated geometries, loadings, and material properties where analytical solutions cannot be obtained.

Materials:-
The general materials used are the manufacturing of the chassis are steel, aluminum alloy and magnesium alloy.
Alloy steel have a little carbon but mainly have other metals to give them various properties, such as strength form nickel, corrosion resistance from chromium, toughness from vanadium, hardness from manganese, improved wear from molybdenum and high temperature strength from tungsten.
Aluminum (Al) die casting alloys have a specific gravity of approximately 2.7 g/cc, placing them among the lightweight structural metals. Six major elements constitute the die cast aluminum alloy system: silicon, copper, magnesium, iron, manganese, and zinc. Each element affects the alloy both independently and interactively. Alloy 218 (ANSI/AA 518.0) provides the best combination of strength, ductility, corrosion resistance and finishing qualities.
Magnesium (Mg) has a specific gravity of 1.74 g/cc; making it the lightest commonly used structural metal. Alloy AZ91D is the most widely-used magnesium die casting alloy. It is a high-purity alloy with excellent corrosion resistance, excellent cast ability, and excellent

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strength. Corrosion resistance is achieved by enforcing strict limits on three metallic impurities: iron, copper and nickel. It basically consists of three metals aluminum, zinc and magnesium.

III. METHODOLOGY

In order to achieve objective the following methodology is selected.

1. A hybrid structure made by combining ladder and backbone chassis concept.
2. Basically work of this research is concentrated on behavior of the chassis on varying the manufacturing material.
3. Need to find maximum deformation, maximum stress and strain on the chassis when made by steel, aluminium alloy, and magnesium alloy under the applied load.

Load Applied: - 1500N
Constraints applied: - i) Bottom of the front member.
ii) Bottom of the Rear Member.

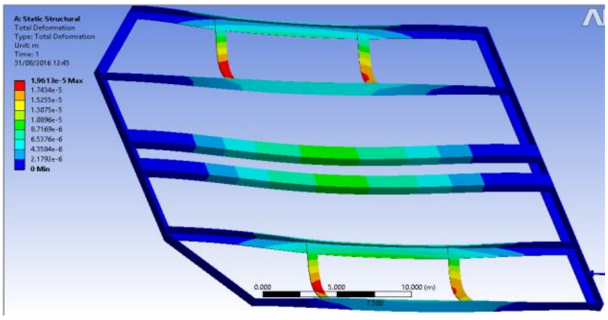
IV. RESULTS

The analysis done gives the following results:-

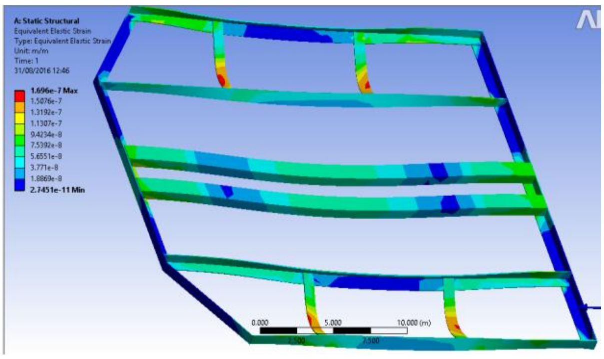
S.No	Material used	Deformation(mm)	Stress(Pa)	Strain
1	Steel	1.9613×10^{-2}	Max – 33499 Min- 4.556	Max-1.69×10^{-7} Min-2.74×10^{-11}
2	Aluminium alloy	1.738×10^{-1}	Max- 2.337×10^{5} Min-6.972×10^{-1}	Max-2.89×10^{-6} Min- 2.25×10^{-8}
3	Magnesium alloy	9.849×10^{-2}	Max-2.383×10^{5} Min-6.984×10^{-1}	Max-1.86×10^{-6} Min-1.605×10^{-8}

The following picture (Pic 1 to Pic 9) shows the deformation, stress developed and stain developed in the chassis.

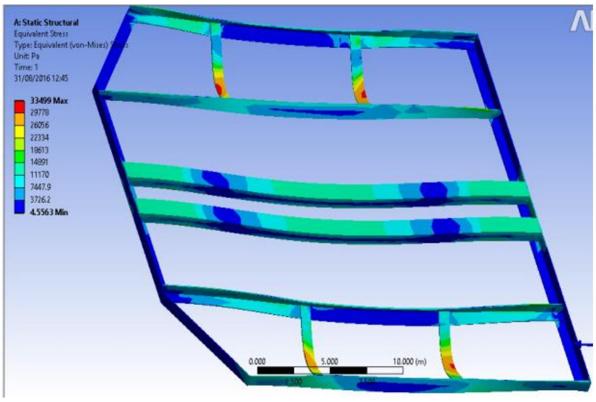
1) For chassis made of steel:-



Pic 1: Total deformation for the steel chassis

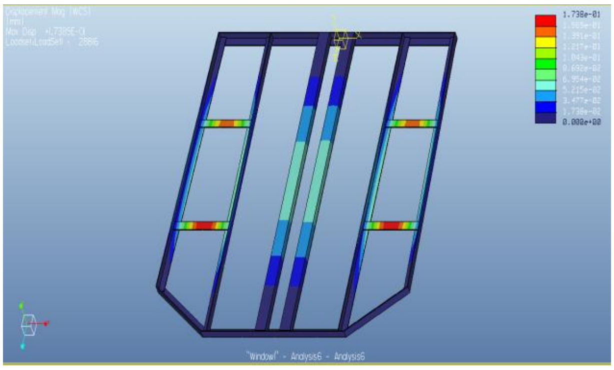


Pic 2: Equivalent elastic strain for the steel chassis



Pic 3: Von-Mises stress for steel chassis

2) For chassis made of Aluminium alloy:-



Pic 4: Total deformation for aluminium alloy chassis

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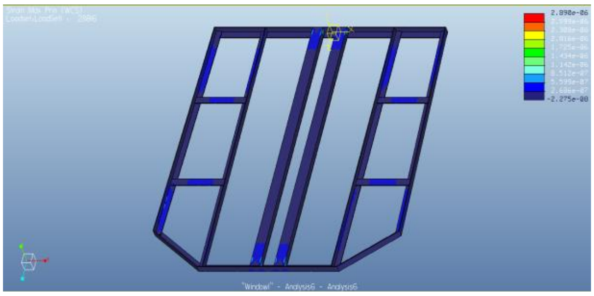
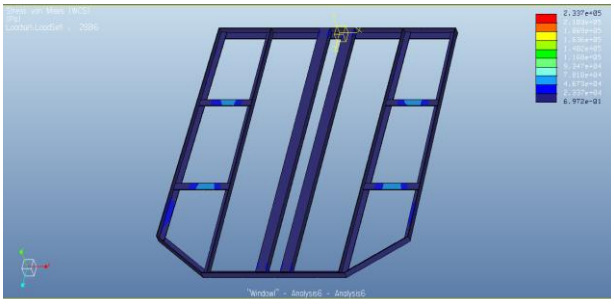
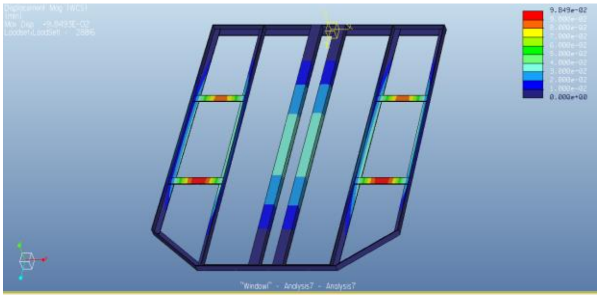


Pic 5:-Equivalent elastic Strain for Aluminium alloy

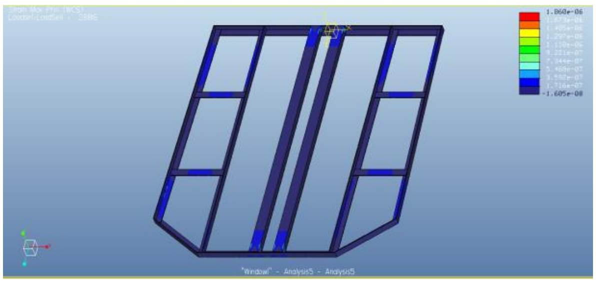


Pic 6: Von-Mises stress for aluminium alloy

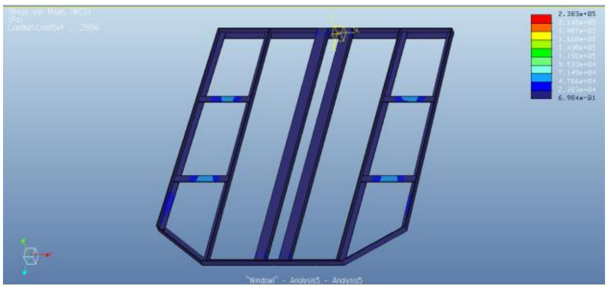
3) For chassis made of magnesium alloy:-



Pic 7: Total deformation for magnesium alloy



Pic 8: Equivalent elastic strain for magnesium alloy



Pic 9: Von-Mises Stress for magnesium alloy

V. CONCLUSION

Form the above result it can be concluded that:

1) It is observed that for the taken materials, the minimum deformation observed is in order Steel<Magnesium alloy<Aluminium alloy.
2) The order obtained for the stresses developed in different materials is Steel< Magnesium alloy < Aluminium alloy.
3) Maximum strain obtained is in aluminium alloy, moderate in magnesium alloy & minimum in Steel.
4) Thus the main load bearing element of chassis should be made of the steel.

REFERENCES

i) P. S Madhu., T. R. Venugopal RADIOSS is used as solver for the analysis, they found that location of maximum Von Misses stresses and maximum shear stresses are just near the support and at the joining portion of connecting plates and side rail. These stresses can be minimized by relocating the position of the cross members and deflection of the chassis side members can be reduced considerably. [May2014.]

ii) H. Patel, K. C. Panchal and C. S.Jadhav have work performed towards the optimization of the automotive chassis with constraints of maximum shear stress, equivalent stress and deflection of chassis. For optimization of chassis different cross sections are selected by changing the height and width of side members and cross members. [April-2013.]

iii) K. I. Swami, Prof. S. B. Tuljapure considered Eicher 20.16 ladder chassis and they have studied the effect of varying thickness on chassis. They found that at the free end of beam highest deformation has occurred leading to lowest stresses. Deformation and stresses are directly proportional to load applied. As the thickness of cross members increases there is decrease in von misses stress and deformation. [February 2014.]

iv) J. S. Nagaraju, U. H. Babu has replaced the traditional material of chassis i.e. steel & Aluminum with Composite Material Carbon Epoxy and E glass Epoxy. By observing structural Analysis results the stress values for Carbon Epoxy and E glass Epoxy are less than their respective allowable stress values. So using composite for chassis the weight of the chassis reduced 4 times than by using steel because density of steel is more than the composites. [January March, 2012.]

v) H. B. Patil, S.D. Kachave and E. R. Deore have selected ladder chassis of truck. They have selected different thicknesses for cross members and side members of truck. They have suggested that in order to achieve a reduction in the magnitude of stress at critical point of the chassis frame, side member thickness, cross member thickness and position of cross member from rear end were varied. Finally they have suggested that to change the thickness of cross member at critical stress point than changing the thickness of side member and position of chassis for reduction in stress values and deflection of chassis[Mar. - Apr. 2013]