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ANALYSIS OF ALUMINIUM ALLOY MADE CHASSIS FOR HEAVY DUTY VEHICLE WITH COMPARATIVE STATIC STRENGTH ANALYSIS

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Abstract: *Aluminium was successfully used as the material for the chassis frame, a main structural member of heavy-duty trucks, to significantly reduce the truck weight and so allow the payload to be increased. The shape and configuration of the aluminum frame design were optimized while maintaining strength and rigidity equivalent to those of a standard steel frame by using computer-aided-engineering analysis. The stress analysis is important in life prediction of components to determine the critical point which has the highest stress. In this paper were are going to change the material of the chassis frame instead of using cast iron. The values of the equivalent stress, equivalent strain and total deformation are compared between cast iron,A354 alloy and A356 alloy. The analysis was done for a truck model by utilizing a commercial finite element package ANSYS workbench.*

Index Terms **- Truck ,Chassis Frame, Aluminum Alloy, Cast iron, Static Analysis**

I. INTRODUCTION

Aluminium is remarkable for the metal's low density and for its ability to resist corrosion due to the phenomenon of passivation. Structural components made from aluminium and its alloys are vital to the aerospace industry and are very important in other areas of transportation and building. Its reactive nature makes it useful as a catalyst or additive in chemical mixtures, including ammonium nitrate explosives, to enhance blast power.

About 85% of aluminium is used for wrought products, for example rolled plate, foils and extrusions. Cast aluminium alloys yield cost effective products due to the low melting point, although they generally have lower tensile strengths than wrought alloys. The most important cast aluminium alloy system is Al-Si, where the high levels of silicon (4.0% to 13%) contribute to give good casting characteristics. Aluminium alloys are widely used in engineering structures and components where light weight or corrosion resistance is required.

II. LITERATURE REVIEW

several research and studies are carried on usage of aluminum alloy as a alternative material for automobile chassis frame.

Among these works, Vishal Francis, et al[9] carried out analysis Structural Analysis of Ladder Chassis Frame for Jeep Using Ansys .The results obtained shows that Von mises stress and shear stress were found minimum in aluminium alloy for statics load conditions.

Another work regarding, Design & Analysis of Automobile Chassis carried out by Hari Kumar, A. and Deepanjali[5], V shows Shear stresses were found minimum in Aluminum alloy 6063-T6 and Von Mises stresses were found minimum in Aluminum alloy 6063-T6.

Another work of structural static analysis of the truck chassis using Ansys workbench is presented by Vijaykumar V. Patel et al. [8]. A comparison between analytical and numerical results was presented. The numerical simulation obtained by Ansys for the Von Mises and shear stress was bigger 10% than result of the analytical calculation. This static analysis was performed to obtain the maximum stress and shear deformation of the chassis using static loading to be able to evaluate the capacity of the total frame.

Mukesh Patil et al. [1] made a static and modal analysis by using Ansys Workbench for a tanker truck chassis to be able to evaluate maximum stress and natural frequencies of the frame. The results show that the maximum stress exceeds the ultimate tensile strength indicating that the structure is not safe. In this case, more investigations should be applied regarding design and load caring

The work of Akshay Jain et al. [10] shows the possibility of reducing stress developed in the chassis frame and increase load carrying capacity. The study focused on the static load analysis with different thickness of chassis frame. The results show a weight reduction of about 1.2% and an increase in capacity by 40%.

III. ALUMINIUM ALLOY

3.1.Need for Aluminium Alloy Chassis

1.Aluminum is extensively used for automotive chassis and engine applications.
2. Future Hybrid and Electro automobiles need lightweight designing materials like Aluminum because Batteries are heavy.
3. Properties like useful strength, low density, high thermal conductivity, excellent machining behavior and good corrosion resistance are the main reasons for using Aluminium alloys.
4. Despite the higher cost of Aluminum alloys the usage has increased in the past Years for lightweight components.
5. With new production processes Aluminum alloys can pass a strength level of more than 1.000 MPa. A direct substitution of Steels seems to be achievable

3.2. List of Symbols, Abbreviations and Nomenclature

1. m = Metre
2. Kg = kilogram
3. K = Kelvin
4. J = Joule
5. Pa = Pascal
6. C = Celsius
7. psi = pounds per square inches
8. m^3=Volume
9. N = Newton
10. m^2= Area

Table. 3.1 Aluminium Alloys - Mechanical Properties
(psi (lb/in^2) = 6,894.8 Pa (N/m^2))

Alloy	Tensile Strength *(10^3 psi)*	Elongation *(%)*	0.2% Yield Strength *(10^3 psi)*
A354	47 - 55	2 - 5	36 - 45
A356	38 - 40	3 - 10	28 - 36
A357	33 - 50	3 - 9	27 - 40

3.3 Properties of Aluminium Alloys Grades

Cast Iron:

Young's modulus = 160×10^{10} Pa
Poisson's ratio = 0.29
Density = 6600 kg/m^3
Thermal expansion = 5.8×10^{-5} 1/°c
Specific heat = 460 J/kg^0c
Resistivity = 9.7×10^{-8} ohm.m

A354 alloy:

Young's modulus = 71×10^{10} Pa
Poisson's ratio = 0.33
Density = 2770 kg/m^3
Thermal expansion = 2.3×10^{-5} 1/°c
Specific heat = 875 J/kg^0c
Resistivity = 5.7×10^{-8} ohm.m

A356 alloy:

Young's modulus = 71×10^{10} Pa
Poisson's ratio = 0.33
Density = 2750 kg/m^3
Thermal expansion = 2.14×10^{-5} 1/°c
Specific heat = 855 J/kg^0c
Resistivity = 5.45×10^{-8} ohm.m

IV. RESEARCH METHODOLOGY

4.1Technical Specifications

Vehicle Model : Eicher Pro 1110
Length of the frame = 750 cm = 7500 mm
Breadth of the frame = 92.5 cm = 925 mm
Height of the frame = 20 cm = 200 mm

Cross section area:

Length of cross section = 7.5 cm = 75 mm
Thickness = 5 cm = 50 mm
Height of cross section = 20 cm = 200 mm

4.2 Basic Concept of FEA

1. Divide the domain in which the analysis is to be carried out.
2. Isolating one of the elements from each type and get the property of them.
3. Assembling the finite element to get the property of the whole domain.

4.3.Procedures of FEA

1. Preprocessing phase of FEM - Discretization, numbering.
2. Analysis phase of FEM - Selection displacement, defining material behavior, derivation of element equation, assembling, applying boundary conditions, solution.
3. Post processing of FEM - Result

4.4.**Type Of Structural Analysis**

a. Static analysis
b. Modal analysis
c. Harmonic analysis
d. Transient dynamic analysis

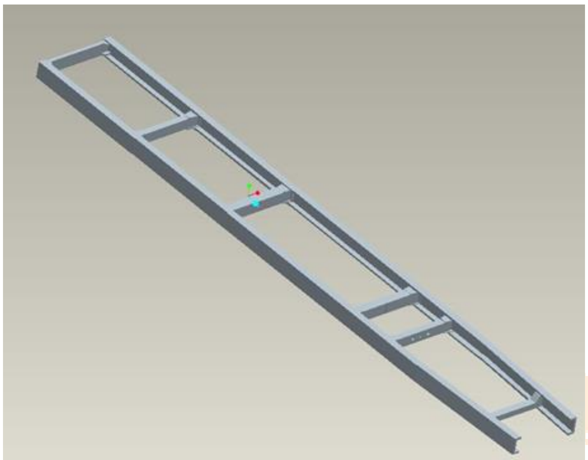

Figure.3.1 3D Model

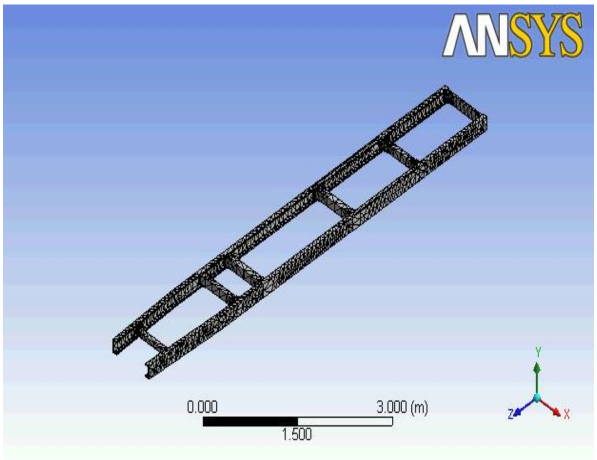

Figure.3.2 Mesh Model

A.Cast Iron:

Maximum stress = $1.179{\times}10^5\ N/m^2$

Maximum strain = 1.0725×10^{-6}

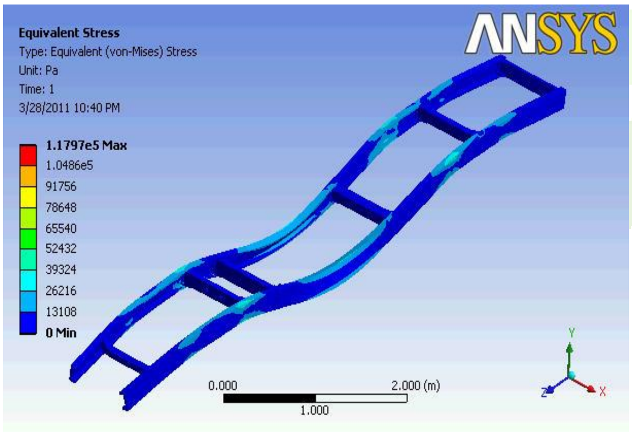

Figure.3.3.Equivalent Stress

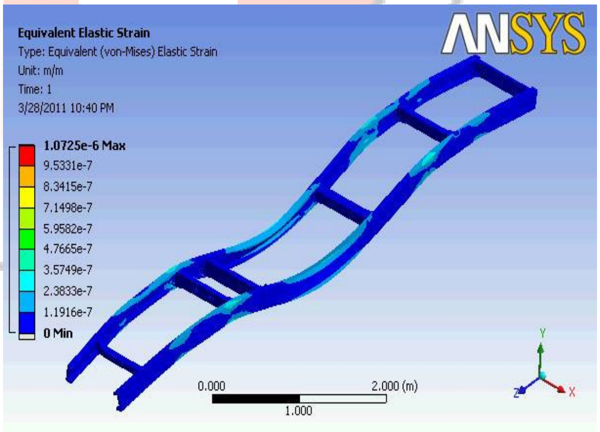

Figure.3.4.Equivalent Strain

Maximum deformation = $2.2598{\times}\ 10^{-6}$m

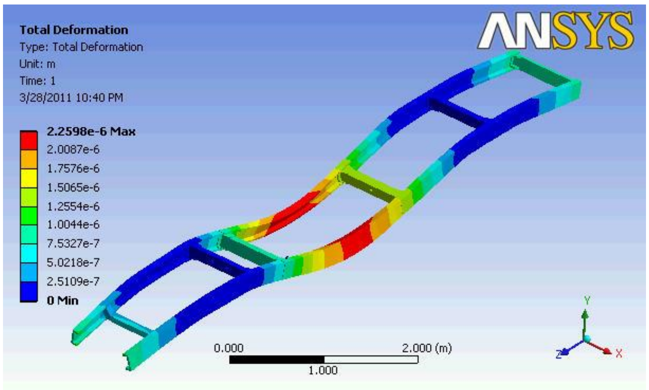

Figure.3.5.Total Deformation

B. A354 Alloy:

Maximum stress = $1.139\times10^5\ N/m^2$

Maximum strain=1.5688×10^{-6}

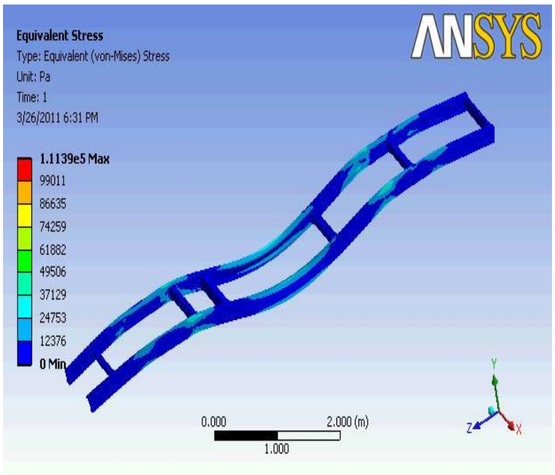

Figure.3.6.Equivalent Stress

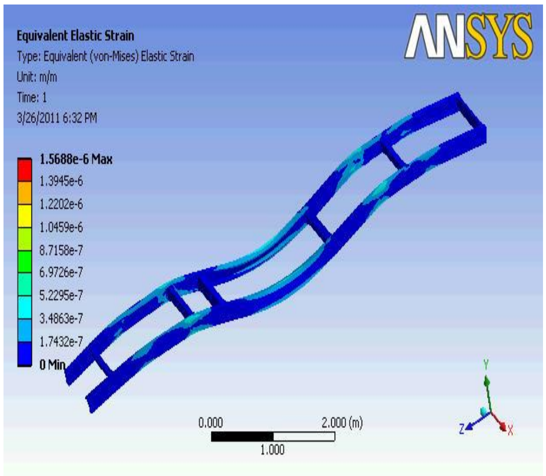

Figure.3.7.Equivalent Strain

Maximum deformation = 3.5031×10^{-6} m

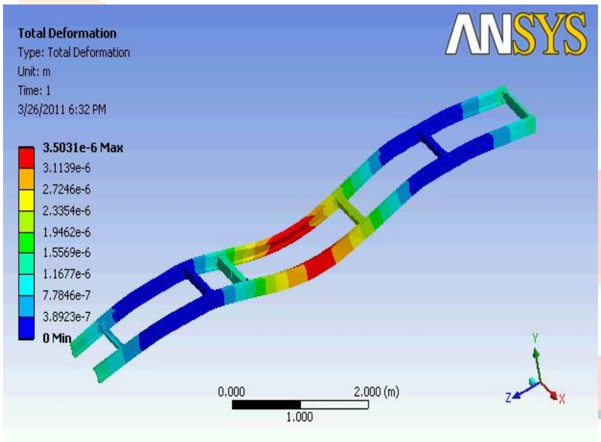

Figure.3.8.Total Deformation

C. A356 Alloy

Maximum stress=$97441\times10^5\ N/m^2$

Maximum strain=1.3724×10^{-7}

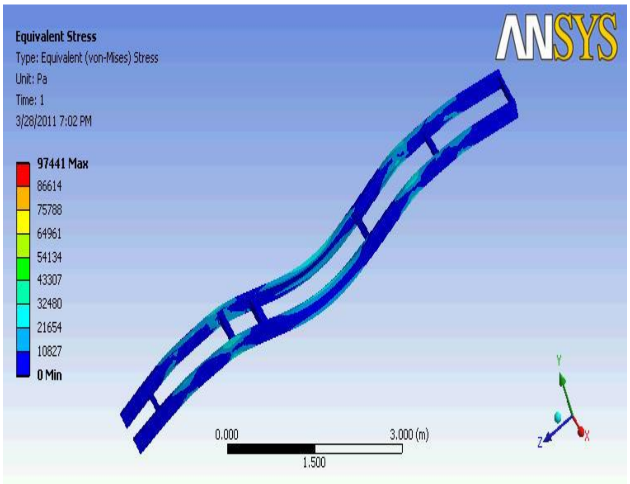

Figure.3.9.Equivalent Stress

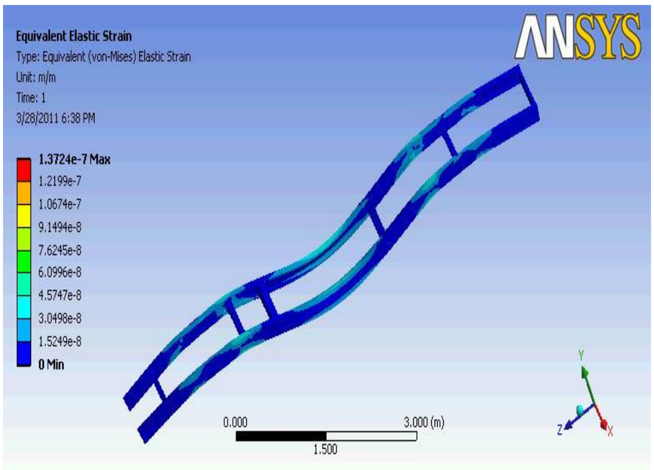

Figure.3.10.Equivalent Strain

$$\text{Maximum deformation} = 3.3264 \times 10^{-7}\text{m}$$

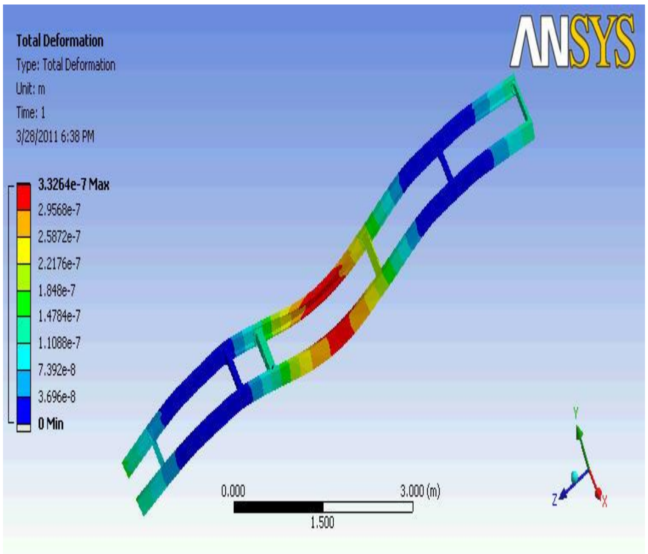

Figure.3.11.Total Deformation

IV. RESULTS AND DISCUSSION

Table.4.1.Comparison of analysed parameters

Alloy grade	Total deformation (m)	Equivalent Stress (Pa)	Equivalent strain
Cast iron	2.2568×10^{-6}	1.179×10^{-5}	1.072×10^{-6}
A354	3.503×10^{-6}	1.113×10^{-5}	1.5688×10^{-6}
A356	3.326×10^{-6}	97441	1.3724×10^{-6}

4.1.Total Deformation

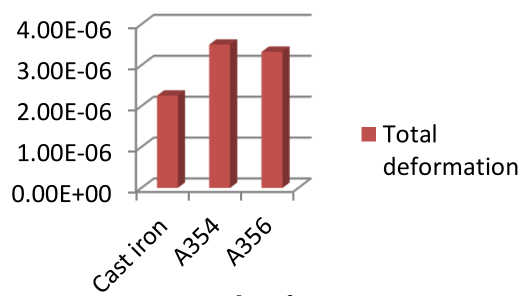

Fig.4.1Total Deformation

From the above chart, it is clearly seen that the total deformation of the A356 is less when compared with that of the A354. Thus the deformation of A356 alloy will be minimum under static loading condition.

4.2.Equivalent Stress

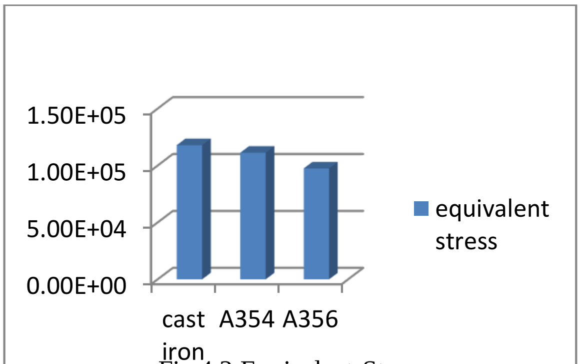

Fig.4.2 Equivalent Stress

The above chart shows the comparison of the equivalent stress of the cast iron, A354 alloy, A356 alloy. In this the stress existing in cast iron is more compared to A356alloy and A354 alloy. So chances of failure due to increase in stress is more but incase of A356 alloy its is less.

4.3.Equivalent Strain

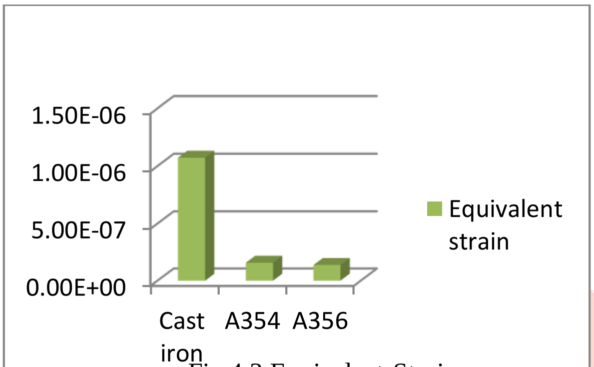

Fig.4.3.Equivalent Strain

This chart shows strain comparison of the different material. The strain value of the A356 is minimum when compared with cast iron, A354 alloy. Thus the change in dimensional parameter or any other parameter in less, so its suitable for using A356 alloy as material for chassis frame.

4.4.Conclusion

Thus from static load analysis of the aluminium alloy grades A354, A356 and cast iron, it's very clear that use of A354 alloy in chassis frame application will be very effective. If A356 alloy is used it will results in major reduction in the weight of the chassis frame and load carrying capabilities is increased when compared to the A354 alloy. As the total deformation of the A356 is less when compared with that of the A354 alloy, A356 alloy will go for less deformation for the heavy duty applications. Therefore from the above results it's found that A356 alloy is best suited for use of chassis frame for heavy duty vehicles.

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