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Design and Structural Analysis of Ashok Leyland Lorry Chassis

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Abstract:
Automotive chassis is a skeletal frame on which various mechanical parts like engine, tires, axle assemblies, brakes, steering etc. are bolted. The chassis is considered to be the most significant component of an automobile. It is the most crucial element that gives strength and stability to the vehicle under different conditions. Automobile frames provide strength and flexibility to the automobile. The backbone of any automobile, it is the supporting frame to which the body of an engine, axle assemblies are affixed. Tie bars, that are essential parts of automotive frames, are fasteners that bind different auto parts together. This paper describes Design and structural analysis of conventional type heavy lorry vehicle frame. In the present work, the dimensions of an existing heavy lorry chassis of a vehicle are taken for modeling and analysis with different materials subjected to the different load conditions of the steel chassis to test their maximum working conditions on different situations for the most suitable materials. The stressed and failure regions are identified and their reasons of failure are observed and steps to overcome are sorted. The various steel alloy materials used for the chassis are grey cast iron, structural steel AISI 4130 alloy steel, AISI A 514 GRADE B alloy steel, A709M GRADE 345 W alloy steel and coming to composite materials like carbon/epoxy, E-glass/Epoxy& S-Glass/Epoxy are used. The three dimensional solid Model was built in the CAD software CATIA V5 R20 and the analysis was done in ANSYS WORKBENCH 17.0.

Keywords: Grey cast iron, AISI A514 GRADE Alloy steel, `A 709M GRADE 345W structural steel, AISI 4130 Alloy steel, physical Properties, Chemical properties, carbon/epoxy, E-glass/Epoxy, S-Glass/Epoxy, Reverse Engineering & Re-Engineering

I.INTRODUCTION

Automotive chassis is a French word that was initially used to represent the basic structure. It is a skeletal frame on which various mechanical parts like engine, tires, axle assemblies, brakes, steering etc. are bolted. It gives strength and stability to the vehicle under different conditions. At the time of manufacturing, the body of a vehicle is flexibly molded according to the structure of chassis. Automobile chassis is usually made of light sheet metal or composite plastics. It provides strength needed for supporting vehicular components and payload placed upon it. Automotive chassis or automobile chassis helps keep an automobile rigid, stiff and unbending. It ensures low levels of noise, vibrations and harshness throughout the automobile. Automobile chassis without the wheels and other engine parts is called frame. Automobile frames provide strength and flexibility to the automobile. The backbone of any automobile, it is the supporting frame to which the body of an engine, axle assemblies are affixed. Tie bars that are essential parts of automotive frames are fasteners that bind different auto parts together. Automotive frames are basically manufactured from steel. Aluminum is another raw material that has increasingly become popular for manufacturing these auto frames. In an automobile, front frame is a set of metal parts that forms the framework which also supports the front wheels.

1.1 Types of frames there are three types of frames
1. Conventional frame
2. Integral frame
3. Semi-integral frame

1.1.1 Conventional frame It has two long side members and 5 to 6 cross members joined together with the help of rivets and bolts. The frame sections are used generally. a. Channel Section – Good resistance to bending b. Tabular Section – Good resistance to Torsion c. Box Section – Good resistance to both bending and Torsion.

1.1.2 Integral frame This frame is used now in most of the cars. There is no frame and all the assembly units are attached to the body. All the functions of the frame carried out by the body itself. Due to elimination of long frame it is cheaper and due to less weight most economical also. Only disadvantage is repairing is difficult.

1.1.3 Semi – Integral frame In some vehicles half frame is fixed in the front end on which engine gear box and front suspension is mounted. It has an advantage when the vehicle is met with an accident the front frame can be taken easily to replace the damaged chassis frame. This type of frame is used in American and European cars.

1.2 Functions of the frame
1. To carry load of the passengers or goods carried in the body.
2. To support the load of the body, engine, gear box etc.,
3. To with stand the forces caused due to the sudden braking.
4. To with stand the stresses caused due to the bad road condition.
5. To with stand centrifugal force while cornering.

1.3 Various loads acting on the frame
1. Short duration Load – While crossing a broken patch.
2. Momentary duration Load – While taking a curve.
3. Impact Loads – Due to the collision of the vehicle.
4. Inertia Load – While applying brakes.
5. Static Loads – Loads due to chassis parts.

6. Over Loads – Beyond Design capacity.

II. SPECIFICATION OF THE PROBLEM

The present work describes mainly about the design and structural analysis of a heavy lorry chassis with the present material and also different types of alloys & composite materials Viz., Grey cast iron, AISI A514 GRADE B Alloy steel, AISI 4130 Alloy steel, epoxy/carbon, S-glass/epoxy & E-glass/epoxy. The solid model of the chassis was created in CATIA V5R20. Model was imported in ANSYS 17.0 for analysis by applying the existing load conditions. The model was tested for stress and deformation as the design constraints. After analysis a comparison is made between existing conventional steel chassis and other material heavy vehicle chassis viz., grey cast iron, AISI 4130 alloy, AISI A514 GRADE B Alloy steel and respective composite materials. And also analysis in fatigue tool and after analysis life and damage comparison is made between the existing and other alloys. This work is mainly carries out due to present scenario where materials are beings rapidly replacing with light weight materials as well as composite in automotive domain with a rapid change. This work mainly carried with reverse and re-engineering techniques.

III.CHASSIS MATERIALS

Currently the material used for the chassis is A709M Grade 345W Structural steel which is known as structure steel.

A 709M Grade 345W chemical composition

- Manganese (0.75-1.35)
- Phosphorus (up to 0.04)
- Silicon (0.15-0.40)
- Carbon (0.20)
- Sulphur (up to 0.05)
- Iron (97.5)

Grey cast iron- The composition of grey cast iron in terms of its entire constituent elements can be explained as follows:

- Carbon (up to 4%)
- Silicon (up to 3%)
- Manganese (0.8%)
- Sulphur (.07%)
- Phosphorus (0.2%)
- Molybdenum (up to 0.75%)
- Chromium (0.35%)
- Vanadium (0.15%)

AISI 4130 alloy steel- AISI stands for the American Iron and Steel Institute, has given the designation to the steel alloy with the particular composition of material like AISI 4130,AISI 4140. AISI 4130 is also known as the chrome-moly alloy steel which stands for chromium-molybdenum alloy steel. The chemical composition of the AISI 4130 steel alloy is given as follows:

- Carbon (0.28-0.33)
- Chromium (0.8-1.1)
- Iron (97.3-98.22)
- Manganese (0.4-0.6)
- Molybdenum (0.15-0.25)
- Phosphorus (up to 0.035)
- Sulphur (up to 0.04)
- Silicon (0.15-0.35)

The followings values show the chemical composition of AISI A514 GRADE B alloy steel.

- Iron 98%
- Manganese 0.85%
- Chromium 0.48%
- Silicon 0.28%
- Molybdenum 0.2%
- Titanium 0.02%
- Carbon 0.12-0.210%
- Vanadium 0.05%
- Boron 0.003

The followings values show the chemical composition of S-Glass epoxy.

- SiO_2 65wt%,
- Al_2O_3 25wt%,
- MgO 10wt%.

IV. SPECIFICATION OF SIX TYRES ASHOK LEYLAND LORRY CHASSIS

Table.1. Parameters of chassis

1	Total length of chassis	7322mm
2	Thickness of chassis	8mm
3	Width of chassis	80mm
4	Density of steel chassis	7850kg/cm^3
5	Back body chassis length	5290.7mm
6	Applying load	98066.5 N(10 ton)
7	Part bodies	257
8	Payload	10 tons
9	Young's modulus of steel chassis	2 e5 N/mm2
10	Front cabin chassis length	2559.3mm

Table.2. Physical properties of alloys

materials	Modulus of elasticity (GPA)	Density Kg/m^-3	Tensile strength (MPA)	Yield strength (MPA)
Grey cast iron	140	7200	450	280
AISI 4130 Alloy steel	190	7850	670	435
AISI A 514 GRADE B Alloy steel	210	7850	760	690
A 709M GRADE 345W structural steel	200	7850	460	260

V. MODELLING OF CHASSIS IN CATIA V5 R20

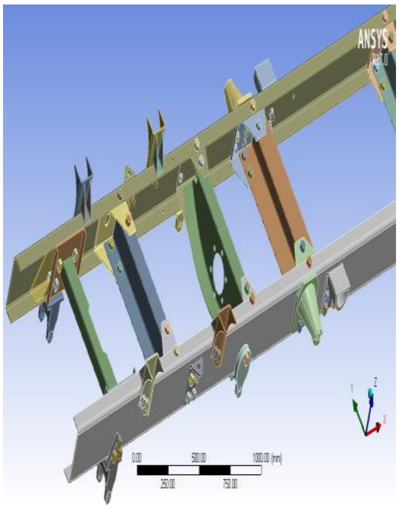


Figure.1. Assembly Design of chassis

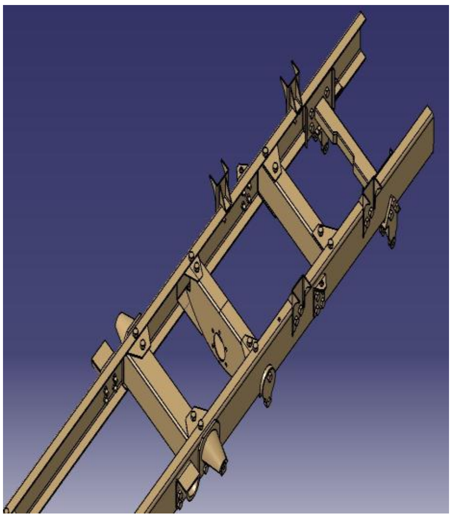


Figure.2. Assembly Design of chassis

VI. STRUCTURAL ANALYSIS OF HEAVY VEHICLE CHASSIS

Start the ANSYS WORKBENCH 17.0 open the software and drag the structural analysis drop into the window and select the engineering data to apply the material to the design and click on to the geometry and the design modeller window opens and click on to the file and import the external file for the analysis and click on to the generate button and go back to the workbench window select the model and the mechanical window opens the model loaded on the screen and select the model to mesh and apply generate mesh and click on to the static analysis in outline box give the loads and the boundary conditions of the chassis and go to solution and select the stresses and deformation and click on to the solve button to Solve the model.

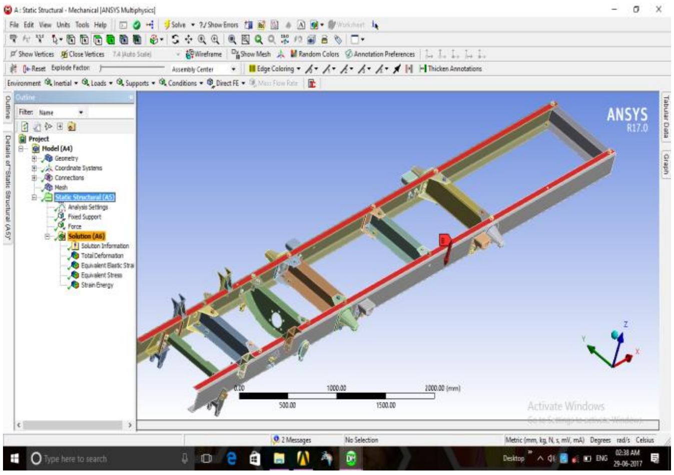


Figure.3.Boundary conditions of chassis

VII. RESULTS AND DISCUSSIONS

STRUCTURAL ANALYSIS OF CHASSIS

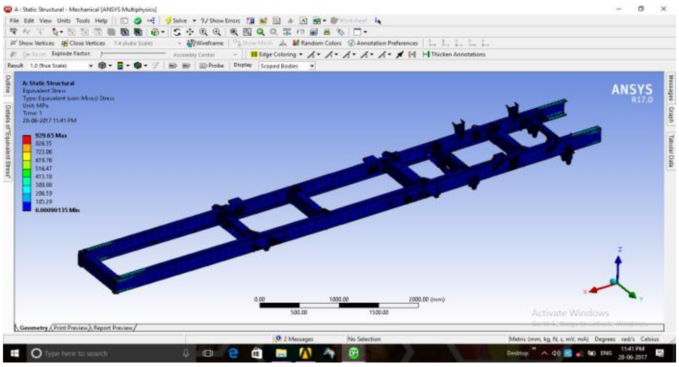


Figure.4. Stress distribution for grey cast iron

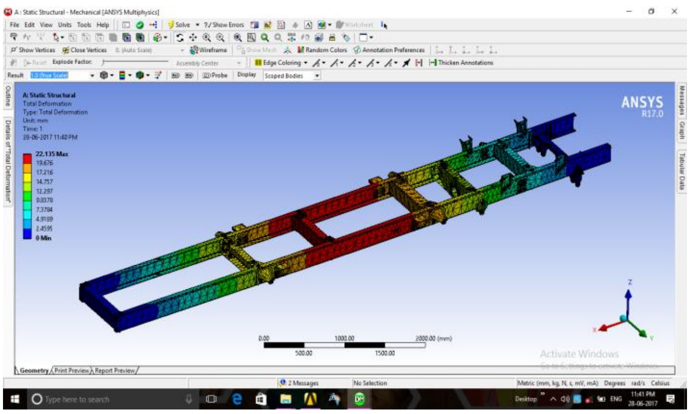


Figure.5. Displacement pattern for grey cast iron

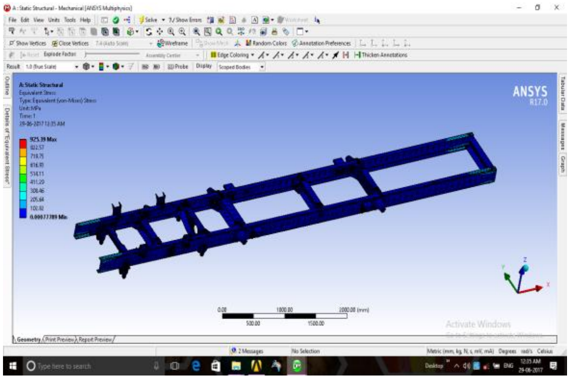


Figure.6. Stress distribution for AISI 4130 steel alloy

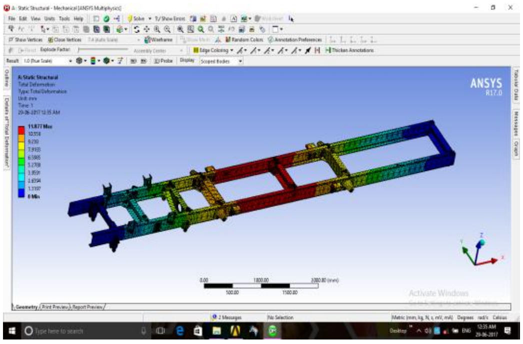


Figure.7. Displacement pattern for AISI 4130 Steel alloy

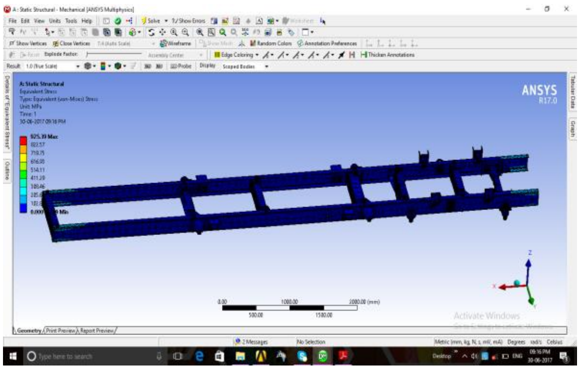


Figure.8. Stress distribution of A709M GRADE 345W alloy steel

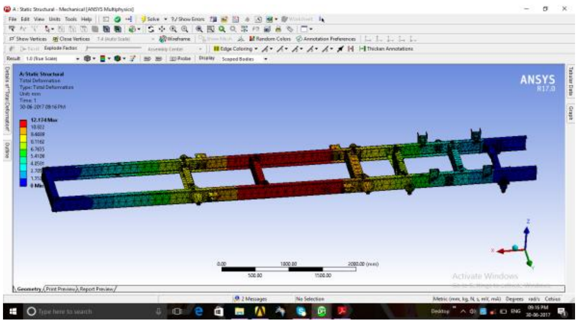


Figure.9. Displacement distribution of A709M GRADE 345W alloy steel

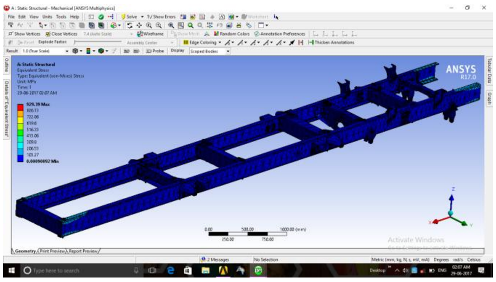


Figure.10. Stress distribution for AISI A514 GRADE B Alloy Steel

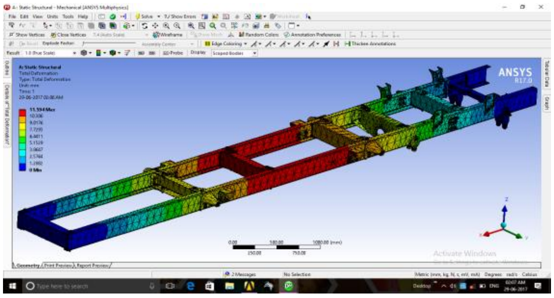


Figure.11. Displacement distribution for AISI A514 GRADE B Alloy Steel

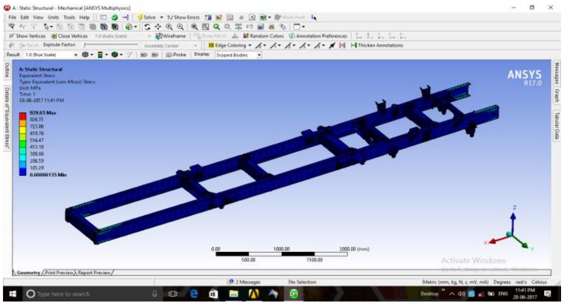


Figure.12. Stress distribution for carbon/epoxy

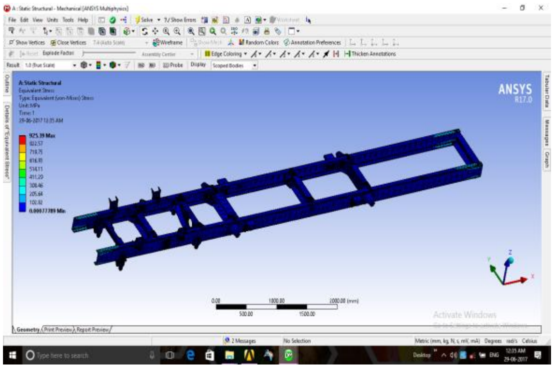


Figure.13. Stress distribution for S-Glass/epoxy

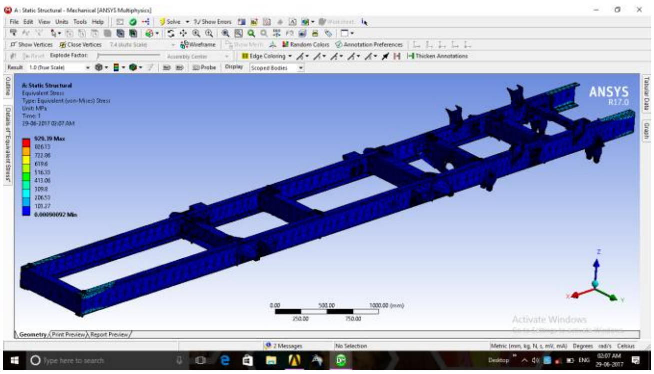


Figure.14. Stress distribution for E-Glass/epoxy

FATIGUE ANALYSIS OF CHASSIS:

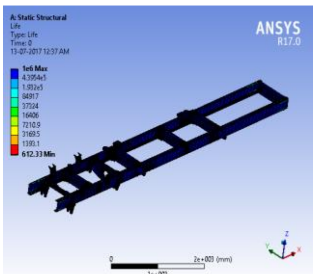


Figure.15. Life for AISI A514 GRADE B

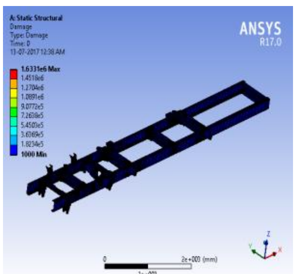


Figure.16. Damage for AISI A514 GRADE B

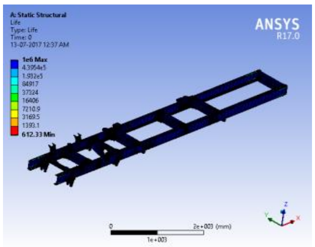


Figure.17. Life for Grey cast iron

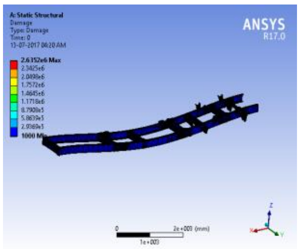


Figure.18. Damage for Grey Cast iron

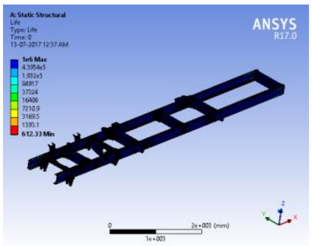


Figure.19. Life for A 709M GRADE 345W

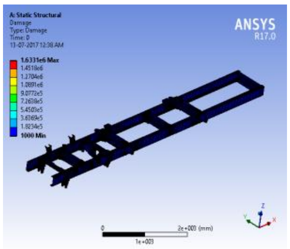


Figure.20. Damage for A 709M GRADE 345W

Table.3. Comparative analysis of structure steel vehicle chassis and other alloy steel chassis

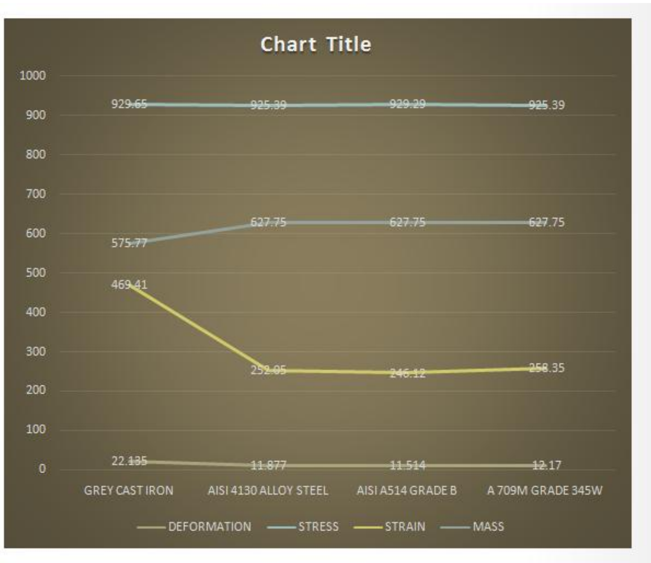
MATERIALS	STRESS (mpa)	DEFORMATION (mm)	STRAIN ENERGY (mJ)	MASS (kg)
AISI 4130 alloy steel	925.39	22.135	252.05	627.75
Grey cast iron	929.65	22.135	469.41	575.77
A 709 M GRADE 345W alloy steel	925.39	12.17	258.35	627.75
AISI A 514 GRADE B alloy steel	929.29	11.514	246.12	627.75
CARBON/ EPOXY	638.99	46.033	214.1	119.43
E-GLASS/ EPOXY	436.9	78.22	327.5	148.29
S-GLASS/ EPOXY	366.8	57.462	231.9	160.31

Table.4. Comparative Fatigue Analysis Of Structural Steel Chassis Over Other Alloy Steels

SLNO	FATIGUE	AISI A514 GRADE B ALLOY STEEL	GREY CAST IRON	A 709M GRADE B ALLOY
1	LIFE Max	1e6	1e6	1e6
2	DAMAGE Max	1.6114e6	2.635e6	1.6331e6

Table.5. Comparative Fatigue Analysis Of Composite Materials

MATERIAL	LIFE Max	DAMAGE Max
Carbon/Epoxy	1e5	1.245e5
S-Glass/ Epoxy	1.25e5	1.782e5
E-Glass/ Epoxy	1.348e5	1.348e5



Graph.1. Comparative analysis of structural steel chassis, other alloy steels & composite materials

VIII. CONCLUSION

The results show that for all of the materials that have been tested in this text, AISI A514 GRADE B steel alloy shows better performance than all of the other metal alloys. It is seen that the material for the chassis i.e. A709M GRADE 345W alloy steel shows strength lower to the AISI A 514 GRADE B steel alloy and also in case of the deformation AISI A 514 GRADE B alloy is superior to structure steel, and also Life is equal for all the materials and damage is lower than all materials. Composite tend to be light weight compared to other alloy materials but in the real application they have certain limits of manufacturing and some due non isotropic nature limits their use even they have high strength and stress bearing capacity. From the result it can also be considered that the AISI a 514 GRADE B alloy is lighter than all of the alloys and on the same side providing the strength as well and and can with stand high stresses compared other alloys tested in this research.

IX. SCOPE FOR FUTURE WORK

There is a high scope for further research in chassis using the composite materials replacing steel alloys to increase strength and weight reduction, but these are cost effective and new methods of fabrication of composite should be considered to have composite chassis which could a game changing in the field heavy automobiles if we succeed.

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