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Investigation of Lightweight materials used in automobile applications

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***Abstract* - Manufacturing of lightweight automobiles are driven by the need to reduce fuel consumption to preserve deteriorating hydrocarbon resources. To meet stringent CO2 standards for the future without compromising other attributes like safety, performance, recyclability and cost. Use of lightweight materials is a concept that has existed since the introduction of automobiles. Today changes in power train strategies, emphasis on fuel economy and reduction of CO2 emission are forcing automakers to make significant changes in material selection. In vehicle design methodology lightweight automobile can be manufactured through any combination of three different approaches. They are lightweight design, lightweight manufacturing and weight reduction through material selection. In order to investigate the weight reduction opportunities in the automobile components a detailed literature review was done in this work and results are presented. Literature review results would form the basis of strategic plans for new product development in automobiles with economic perspective.**

***IndexTerms* – lightweight, automobile components.**

I. INTRODUCTION

The automotive industry has in recent years invited to build lighter vehicles with more fuel-efficient engines for both time reduce fuel consumption and CO2emissions. And improved fuel consumption, driving comfort, environmental responsiveness, and protection are very important one therefore feature among the sales point of view many vehicle manufacturers at present using lightweight materials. The automotive manufacturer carries in developing modern lightweight materials, designs and current technologies. In this work are discussed about replace that steel will remain the primary material for using vehicle structures. However, new high-strength steel grades are using into vehicle structures. The new materials are low density and high strength. The alternative material aluminum and even magnesium are increasing in demand as are future years.

II. LITERATURE SURVEY

Dharmendrasinh Parmar et al. (2015) investigated the16tons YJ3128-type dump truck's sub-frame fatigue cracks. Sub-frame is analyzed by ANSYS 5.1 software [1]. The review has been done bring about the optimized material and the structure. The general reasons for the cracking of the frame have been found. They reasons are high pay load and uneven road conditions. There are proposed new model is six beams in the sub-frame a square beam in the middle and four trough beams. Which are showed in fig.1.In this model minimize the vibration and more stiffness. Future work it will be again calculated and improved this model to obtain better performances.

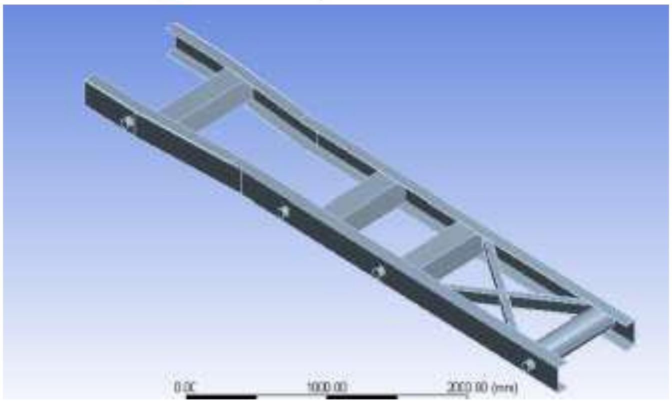

Fig.1

Haresh et al. (2015) had conducted the review work stress analysis of a backhoe chassis [2]. The model of a heavy duty vehicle chassis was developed and optimized by removing unnecessary material and providing stiffener. Also by providing appropriate reinforcement to the chassis, strength will be increased, vibration can be minimized.

Indu Gadagottu et al. (2015) had proposed the conventional materials are replaced with composite materials like S-glass epoxy and E-glass epoxy and analyzed using ANSYS. They are analysis of modified model (honey comb structure) and existing model using mild steel. FRP has been investigated they honeycomb structure are showed in fig.3. They find results are S2-Glass chassis had shown better impact resistance characteristics when compared with Mild steel [3].

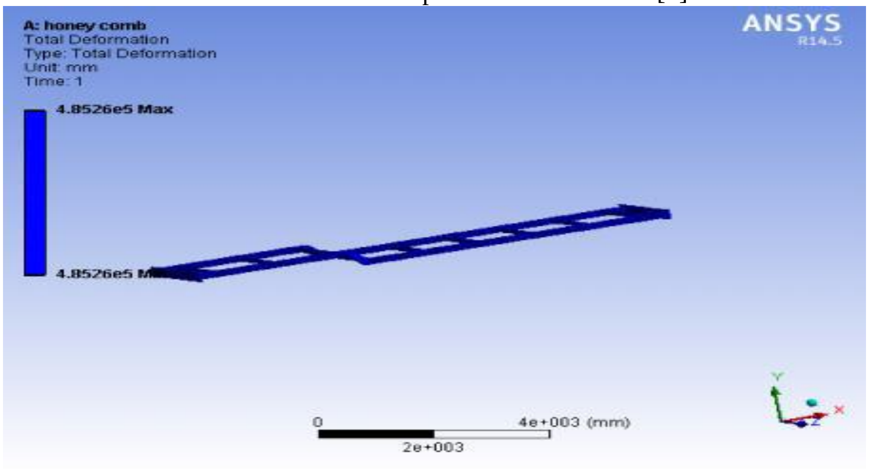

Fig.2

GoollaMurali et al. (2013) had found torsion stiffness and bending stiffness of the truck chassis by finite element method analysis. Further enhancement of the current chassis had been done through the chassis FE model in order to improve its torsional stiffness as well as reduce the vibration level. The new model chassis frame proposed showed in fig.3[4].

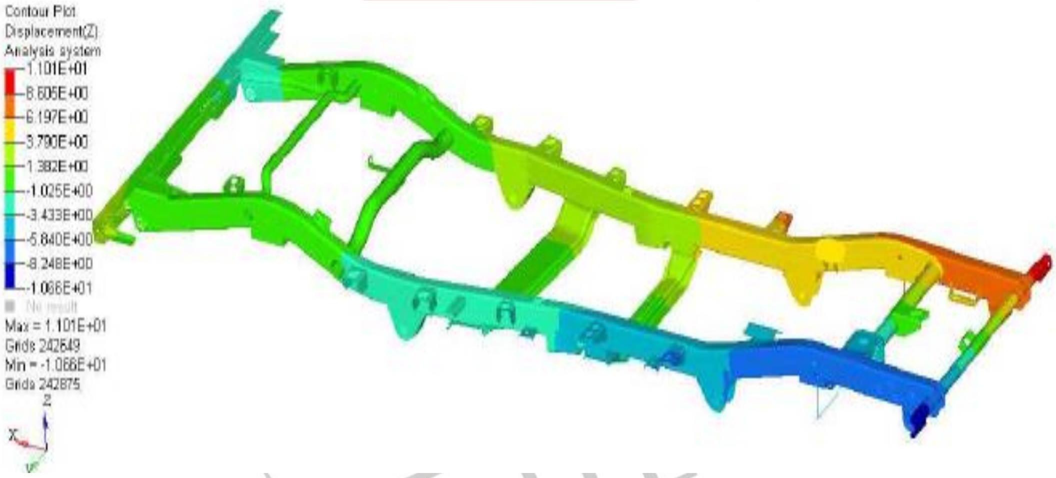

Fig.3

Series of modifications and tests were conducted by adding the stiffener in order to strengthen and improved the chassis stiffness as well as the overall chassis performances improved.

Guruprasad et al. (2013) proposed light weight hybrid aluminium composite (Reinforced with Al2O3 and Fly ash) automobile components. It will take experimentally that the reinforced aluminium with Fly ash and Al2O3 enhances mechanical properties in comparison with monolithic metal. Use finite element analysis to find factor of safety for rear axle housing. Estimate for both hybrid composite and monolithic material. The modified model of axle is given the fig.4 [5].

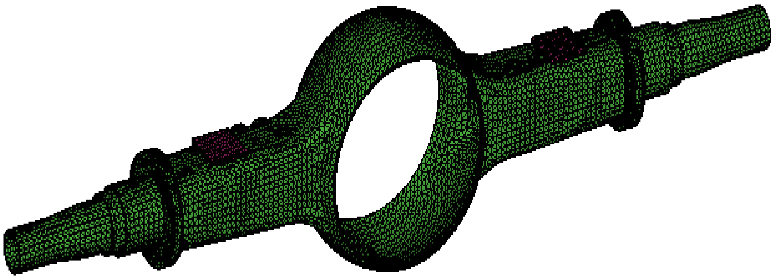

Fig.4

In comparison with the results found for hybrid composite metal and monolithic metal. The composite material analysis results were found to be better than the monolithic metal.

Ashutosh Dubey et al. (2013) had reviewed the load cases & boundary conditions, and stress analysis of chassis using over ANSYS. Shell elements have been used for the longitudinal members & cross members of the chassis. The advantage of using shell element is that the stress details can be obtained over the subsections of the chassis as well as over the complete section of the chassis. Beam elements have been used to simulate various attachments over the chassis. They are measured Impact loads have been experimentally by using accelerometers on the front & rear axles. Input spectrum for Power Spectrum Analysis has been obtained by using FFT Analyzer for the secondary roads at the driving speed of 30 kmph. The structure can be simply assumed as beam, with uniformly distributed load due to cabin & body over its length, and the point loads at the engine and transmission. The result isthe driving speed of 30 kmph is increasing the chassis life high speed is no effect but decreasing chassis life due to more vibration [6].

Ahmad. Moaaz et al. (2014) investigated the different fatigue analysis techniques of heavy duty truck frames. This work related to vehicle optimization, structural design analysis and survey. They are found that the frame analysis generally consists of stress study to prediction the weak points and fatigue analysis to predict the life of the chassis. They are concluding further study and design of truck chassis using Fatigue analysis to improve the chassis life [7].

Ahmed Elmarakbi et al. (2015) investigates efficient ways of develop Graphene polymer reinforcement inside composite materials for efficient –energy and safe vehicles (EESVs).From modeling point of view, this initiative presents strategies to overcome the limitations by developing Graphene appropriate behavior. Finally they are concluding using Graphene based polymer reinforcement in automobile components to minimize the vehicle weight 5-10 % [8].

Teo Han Fui and Roslan et al. (2007) have studied the vibration character of the truck chassis. Include the natural frequencies and mode shape. The responses of the truck chassis which include the distribution of stress and under various loading displacement condition are also observed. Maximum stress occurred at the mounting brackets of the suspension system while the maximum translation occurred at the location where the symmetry and asymmetry load is acting. The maximum stress of the truck chassis is 490 MPa and the maximum translation is 33.6 mm. The result is vibration not change in the truck chassis but high vibration to start the fatigue failure so use vibration absolving or minimizing material reduced chassis failures [9].

Marianna Vivolo et al. (2011) in this paper the vibro-acoustic Properties of structural apparatus base on a new measuring setup, specifically developed for the experimental study of the noise decrease character of lightweight structures. Then test equipment is designed movable and small therefore provide repeatable measures and a desired and predictable low frequency acoustic field. Also the simplicity of the geometry does not requirevery complicated numerical models to acceptable predict the measured behavior in a very wide frequency domain [10].

Ion Florin Popa (2010) had analyzed the new model chassis frame equal resistance method. This type of arrangement uniforms best to the provisions about resistance, constructive simplicity. Analysis by use NISA solver and expert language EUCLID.In order to optimized design structure shown in Fig.5.

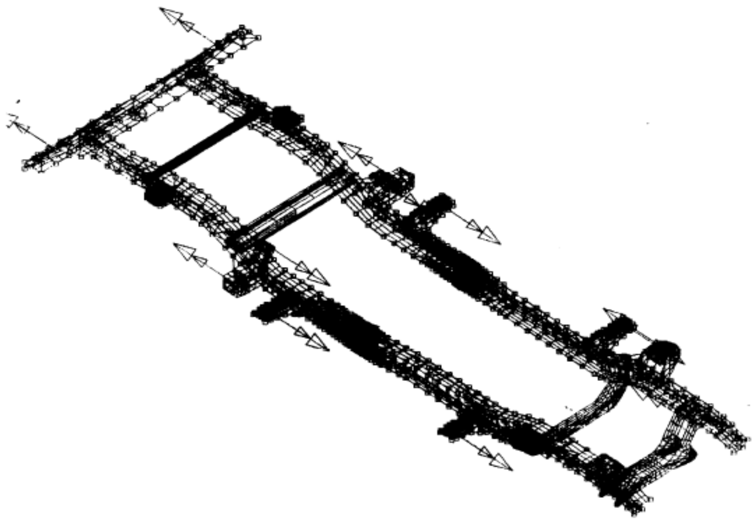

Fig.5

It has been determined the deformation areas, the tension areas and the displacement area of the chassis-type structure. The recommended serial chassis has an increased rigidity and max bend deformation is below 2mm, in most severe stress conditions. The result of two resistance mode of the side member increases with 38.2% in the rear axle zone with 22.5% in the frontal axle zone [11].

Chinnaraj et al (2008) had conducted the experimental work a create different load condition using quasi-static approximation approach for chassis frames and the stress results obtain are compare with experimental results. From the comparative computational vs. numerical stress results have observed variation would not affect strength of frame rail but would step up fatigue failure. And this point of view to needs further investigation [12].

Ojo Kurdi et al (2010) have focused on the relevance of FEA of cyclic loading on the heavy duty truck chassis. Sub-modeling technique has been applied on the dangerous area in order to find the more reliable, more precise and faster way of simulation. It can be concluded that the static load is a main factor that causes a high stress in the truck chassis. To further research other effects on cyclic loading to the failure of chassis. The data used for reference in stress distribution of chassis for fatigue life prediction of truck chassis. [13]

Roslan Abd Rahman et al (2014) was analysis a truck model by utilize a commercial FEA packaged ABAQUS. The chassis model has width of 2.45 m and a length of 12.35 m. The material of chassis is ASTM Low Alloy Steel a 710 C with 620MPa of tensile strength and 552 MPa of yield strength. [14] Detail loading of model is shown in Fig.6

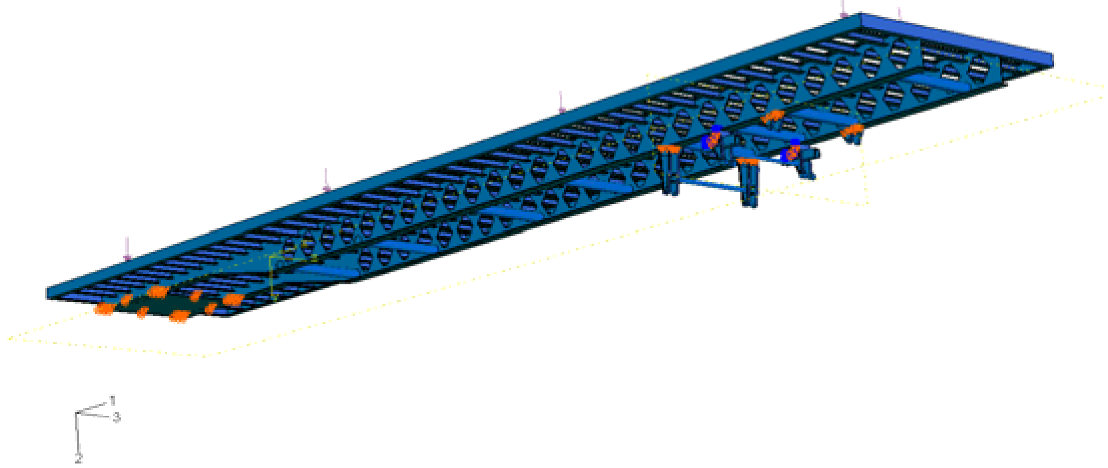

Fig.6

To numerical analysis result the important point of stress occur at chassis which is in contacted with the bolt, the fatigue failure started from the highest stress point. The consented this area to minimizing the high deflections and chassis failures.

Abhishek Singh et al (2014) have taken TATA LP 912 Diesel BS4 bus existing vehicle chassis dimensions is taken for analysis with materials namely Steel alloy (Austenitic) subjected to the same load. But the four different vehicle chassis have been modeled by taking into consideration four different cross-sections [15]. They are I, C, Rectangular Box (Intermediate) and

Rectangular Box (Hollow) type cross sections. For support the design loads applying the vertical acting on the horizontal different cross sections. They are I, C, Rectangular Box,CAD Model cross section is show in fig.7.

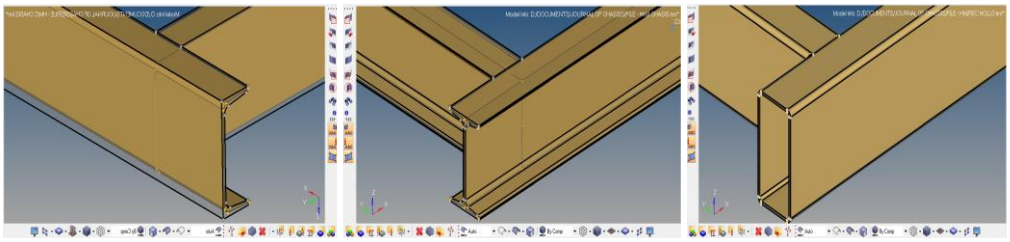

Fig.7

The results, it is found that the Rectangular Box (Intermediate) section is high strength full than the usual steel alloy chassis with C, I and Rectangular Box (Hollow) section design requirement. And they are achieved new information are to improve performance, geometry has been modified which enables to reduce stress levels marginally well below yield limit.

Hirak Patel et al (2013) had optimized of the automotive chassis with constraint of maximum shear stress, deflection and equivalent stress of chassis. Structural system similar to the chassis can be analyzed using the finite element technique. A compassion analysis is carried out for weight reduction. So develop proper FEM model of the chassis. The chassis is designed in PRO-E [16]. Different cross section chassis model show in fig.8.

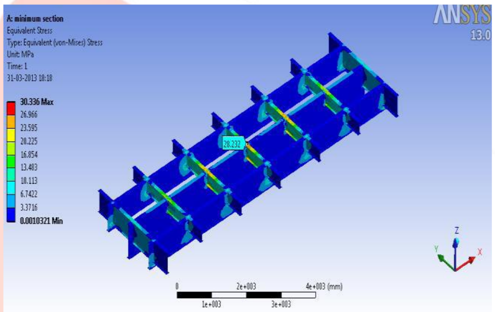

Fig.8

In compassion analysis different cross section is used for stress analysis and they are finding a 17%the truck chassis weight can be reduced. The stress and deformation are also minimized in compared for the different cross section.

Rajasekar et al (2014)had analyzed the literature on chassis design and discussed in heavy duty automobile chassis mechanical failure casus findings. They are found them main reason in chassis problem is that the vehicle structure and frame must be capable to withstand the overload. It has been found that enough study have not been conducted on uneven section chassis concept. Therefore in this way tofill the gap future research study may be conducton uneven segment chassis concept in automobiles [17].

Jatin Rajpal et al.(2015) deal with the structural analysis of automobile frame of EICHER E2 11.10 PLUS and design change of frame cross-section to reduce weight of the chassis. The automobile chassis weight is reduced using type of design method. Structural Analysis frame with compact rolling over index is done to check for failure. From the below table it can be obviously understood that the net weight of the existing and the modified chassis is nearly equal.[18], The rolling over and Stress Shear Stress Total Deformation for the modified chassis are less than the existing chassis. The results are shown in (Table2.1)

Table-1.1Comparison of Mechanical Properties

S.No	Section	Shear Stress (Mpa)	Max Disp.(mm)	Roll Over Index
1	Existing	202.02	4.4771	0.7587
2	Case 3	178.78	3.4648	0.7587
3	Case 3 modified	165.93	3.4353	0.7227

The above listed table enlists the mechanical properties of chassis frame. Also, the reduce weight the rolling over of the vehicle is achieved. The Rolling over Index of the vehicle is reduced from 0.7587 to 0.7227, which is a near reduction of close to 4.75%. Hence rolling over is reduced. At a point, either weight is reduced by 21.57 kg or rollover index is reduced by 0.036 units as using the same weight reduces rollover.

Monika (2015) had to be find commercial vehicle chassis strength, stiffness and fatigue properties along with stress, vibrations and bending moment. This can be achieving by static and dynamic analysis, combining existing theoretical information and advanced analytical methods. The Chassis is designed by using CATIA and FEA will be using ANSYS [19]. Meshing and Loading and Boundary Condition for chassis without load show fig.9.

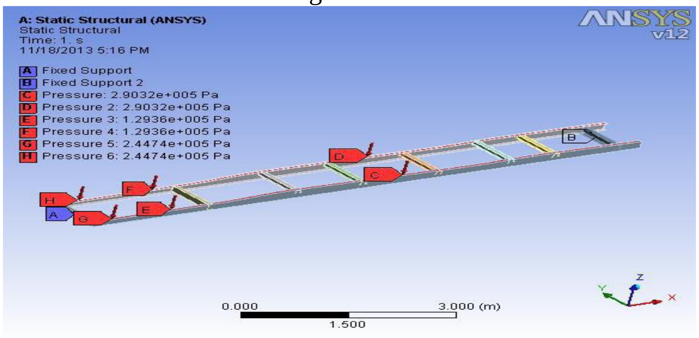

Fig.9

She can find out highly stressed areas of truck chassis. The areas are suspension and bolt joints due to applied high load. From the analysis results, the frequency range of Modal Analysis for Free-Free Condition is 16.89 Hz for applied load Condition 46.316Hz.The Frequency range of both modal analyses for Free-Free Condition and Applied load on truck chassis are in the range 10 to 50 Hz. Almost all of the truck chassis designed were based on this frequency range. So they are proposed above design of chassis is reducing the height of the cross member by 8.6% and weight reduced by 8.72%.

Sameer Kumar (2015) had reviewed the benefits of Mg, Al alloy materials, manufacturing methods and applications in automotive sector. In this work summary the Processing methods, properties, advantages and limitations of magnesium alloys along with automotive applications. The Mg alloys as replacement to aluminum and iron alloys has more advantage. They are high strength and lightweight. The properties, Processing methods, advantages and limitations of magnesium alloys along with automotive applications Mg-Al-Zn alloys offer both strength and ductility at room temperatures with greater flexibility in many applications. Magnesium alloys usage in automotive industry has been substantially increased to reduce the CO_2 emissions, and weight reduction of the vehicle thus increasing the fuel economy. Weight reduction using magnesium in vehicles is interesting and established with good results [20].

Conclusion

The present study has investigated literature related to usage of lightweight materials in automobile parts. Based on the review, following conclusions are drawn.

•Use of lightweight materials for automobile components like chassis and axles are inadequately addressed in the scholarly literature

•Application of Bionic Structure concept in lightweight component development applications finds less attention in the literature

•Use of 3D printing technology for making lightweight components for automobile application has future scope.

•Studies on heavy duty automobile parts with lightweight perspective seems to be less

Hence in order to fill the gap future research studies may be conducted on variable structure and alternative material chassis frame modeling automobiles.

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