FINITE ELEMENT ANALYSIS OF FRONT AXLE FRAME OF HEAVY DUTY TRUCK WITH CI MATERIAL MODEL

[1]M.PORUS PURUSHOTHAMAN [2]V.JAYACHANDRAN

[1]M.E CAD/CAM, Sembodai Rukmani Varatharajan Engineering College, Sembodai,

E-MAIL:-hyilathburushottman@gmail.com

2Assistant Professor, Dept of Mechanical, S. R.V Engineering College, Sembodai.

E-MAIL:-jaychand.mech@gmail.com

***ABSTRACT* - Present off-highway vehicle market demands low cost and light weight component to meet the need of cost effective vehicle with fuel efficient. This in turn gives the rise to more effective use of materials for vehicle parts which can reduce the overall weight with enhanced utility of vehicle for various applications. Weight reduction and simplicity in design are application of industrial engineering etc., the sources of the technique which are used. Stress analysis of front axle of truck combine under static loading conditions resulted from the applied modifications was performed by using finite element method. The commercial finite element package ANSYS version 9.0 was used for the solution of the problem. The front axle requires a properly designed support with high strength and stiffness. Baseline analysis is carried out on the complete front axle assembly to extract the stress and displacement in the system. In Present work theoretical analysis approach is used to make a safer working condition of front axle of truck as well as for stress concentration, weight and cost reduction of existing front axle.**

I. INTRODUCTION

There are many industrial sectors using this truck for their transportations such as the logistics, agricultures, factories and other industries. If any of the excitation frequencies coincides with the natural frequencies of the truck axle, then resonance phenomenon occurs. The axle is fixed to the wheels, fixed to its surroundings and a bearing sits inside the hub with which a wheel revolves around the axle. A front axle is also called as beam axle which is typically suspended by leaf springs. The front axle of a truck is one of the major and very important components and needs to be designed carefully; this part also experiences the worst load condition such as static and dynamic loads due to irregularities of road, mostly during its travel on off road. Therefore it must be resistant to tolerate additional stress and loads. In our project work, analytical analysis approach is used, (By considering Change in materials and change in existing shape and size). A existing front axle is redesigned for the given load condition, then check the actual deflection occurred in existing axle, also different material and different shape axle get design, Select the best axle according to condition. The main purpose of project is to make a safer working condition of trolley axle as well as for stress concentration, weight and cost reduction.

II. LITERATURE REVIEW

Various experiments and numerical methods were adopted by Leon et al. to obtain the stress analysis of a frontal truck axle beam. The results obtained by finite element method were verified experimentally using photo stress. Based on an experimental and numerical analysis of a front axle carried out by Mahanty et al, redesign was carried out for the front axle for weight optimization and easy manufacturability. Three different models were proposed based on ease of manufacturing and weight reduction.

The urgent issues for industrial companies today are how to reduce the time and cost required for developing anew product (Beckert, 1996; Kojima, 2002). Accordingly, they have tried to use the computer's huge memory capacity, fast processing speed and user-friendly interactive graphics capability to automate and tie together other-wise cumbersome and separate engineering or production tasks, thus reducing the time and cost of product development and production. Computer-aided design (CAD), computer-aided manufacturing (CAM), computer-aided engineering (CAE) are the technologies used for this purpose during the product cycle (Lee, 1999).

Leon et al. (2000) used experimental and numerical methods, for the stress analysis of a frontal truck axle beam. The results obtained by finite element method were verified experimentally using photo stress. Mahanty et al. (2001) performed an experimental and numerical analysis of a tractor's front axle. Based on finite element analysis results redesign was carried out for the front axle for weight optimization and easy manufacturability. Five different models were proposed based on ease of manufacture and weight reduction. The results obtained by finite element method were analyzed by thirteen different certification test load conditions. Maly and Bazzaz (2003) used experimental and numerical methods, for design change from casting to welding for an axle casing.

III. METHODOLOGY

During the front axle modelling process, according to the front axle structural characteristics and the subsequent mesh divide ease, it guarantees the front axle's structure characteristic as well as convenience following finite element analysis, and carries on the partial simplification to the front axle structure, thus establishes front axle's finite element computation shell model. Based on the front axle structural characteristics and bear loading conditions to make appropriate assumption, simplify the front axle entity model into reasonable mechanical model, and choice three static analysis conditions, namely the front axle static full load, Impact load, Emergency braking make loading analysis, and set the loading analysis results as finite element modal's loaded load, and come within the linear elastic to calculate respectively the front axle's tensile strength and yield strength in these three conditions. a axle redesign for the three condition, then check the actual deflection occurred in those design, select the best design according to condition During the optimization process the evaluation of the different alternative combination of product design parameter is carried out to achieve one or several objective functions. Generally the design parameters are subject to restrictions and boundary conditions that has to be previously described and defined. Furthermore a search strategy has to be defined to find the combination of design parameters that fulfills the objective functions.

Commonly, during product development existing limitations affect product performance, for example: natural physic laws, material properties, customer specifications, existing standards etc. These limits constraint the product design specifications, in achieving the desired objective functions. One important constraint are permissible stress and strain levels. The optimization process involves following activities:

- Selection of variables that describe the design alternatives
- Selection of objective functions to be minimized or maximized.
- Establishment of restrictions, expressed in terms of design variables, which must besatisfied by any acceptable design.

IV. MATERIAL DESCRIPTION

The front axle is made of AISI 1020 which has the properties as mentioned below:

AISI 1020 is a low hardenability and low tensile carbon steel with Brinell hardness of 119 – 235 . It has high machinability, high strength, high ductility and good weldability. It is normally used in turned and polished or cold drawn condition. Due to its low carbon content, it is resistant to induction hardening or flame hardening. Due to lack of alloying elements, it will not respond to nitriding. However, carburization is possible in order to obtain case hardness more than Rc65 for smaller sections that reduces with an increase in section size. Core strength will remain as it has been supplied for all the sections. Alternatively, carbon nitriding can be performed, offering certain benefits over standard carburizing.

AISI 1020 steel can be largely utilized in all industrial sectors in order to enhance weldability or machinability properties. It is used in a variety of applications due to its cold drawn or turned and polished finish property.

Poisson's Ratio:	0.3
Young's Modulus:	210 GPa
Yield Stress:	250 MPa
Allowable shear stress:	600 MPa
Tensile Ultimate Strength:	460 MPa
Density:	7850 kg/m3

Table 1:Mechanical properties

Chemical Composition

The chemical composition of AISI 1020 steel is:

Element	Content
Carbon, C	0.17 - 0.230 %
Iron, Fe	99.08 - 99.53 %
Manganese, Mn	0.30 - 0.60 %
Phosphorous, P	≤ 0.040 %
Sulfur, S	≤ 0.050 %

Table 2: Chemical Composition

The front axle is made of structural steel which has the properties as mentioned below:

Poisson's Ratio:	0.3
Young's Modulus:	210 GPa
Yield Stress:	250 MPa
Allowable shear stress:	600 MPa
Tensile Ultimate Strength:	460 MPa
Density:	7850 kg/m3

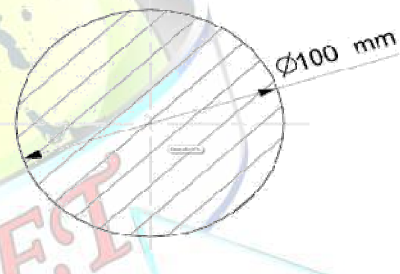
Table 3:Mechanical Material properties

V. CROSS SECTION

The various cross section used in study are a] CIRCULAR C/S,b] SQUARE C/S and c] I SECTION C/S

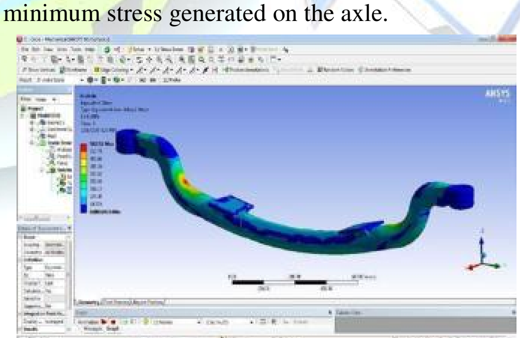
1.CIRCULAR C/S

Fig 2:Circular Cross section



Von Mises stress distribution

The following figure shows the Equivalent (von-mises) stress on the axle when the 6g force is applied. Red color shows the maximum stress and blue color shows minimum stress generated on the axle.



The calculated Von-mises stress is 582 MPa below the material's yielding stress. This means that axle satisfies the safety conditions for maximum loading .but in following figure Red color shows the maximum deformation and blue color shows minimum deformation generated on the axle. Total deformation produced within the axle is 4.063 mm.the total weight of front axle is138.14 kg .

Total Deformation

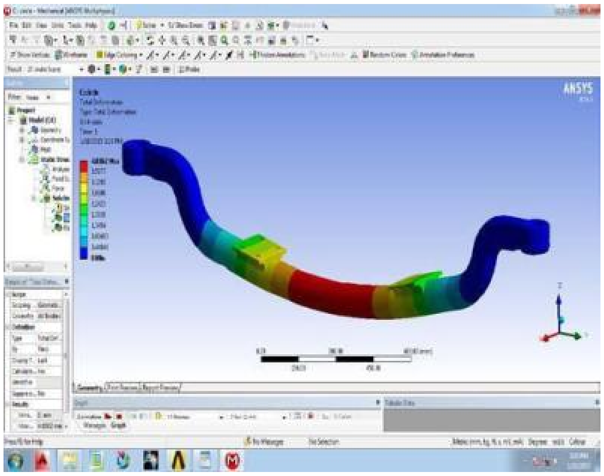
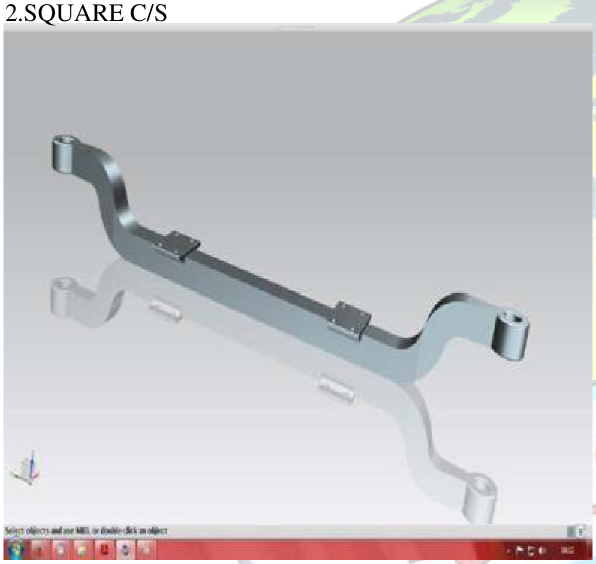


Fig 4:Total deformation

2.SQUARE C/S



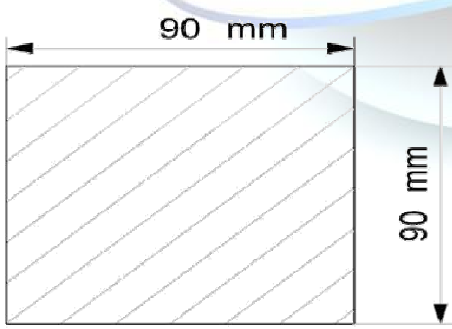


Fig 6:Square Cross-section

Von Mises stress distribution

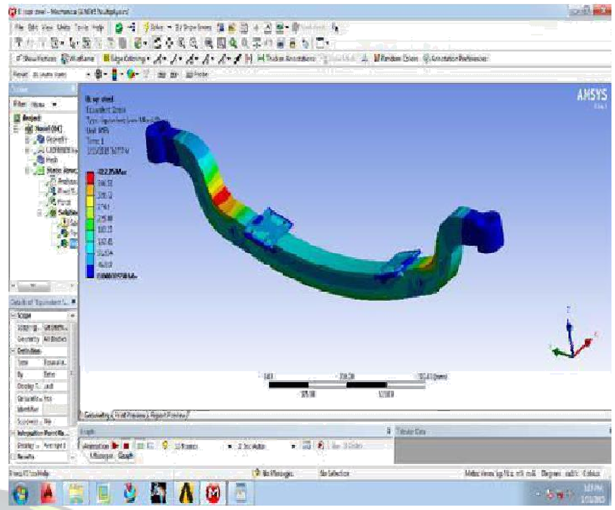


Fig 7:VonMises stress distribution

Volume	1.8064e+007 mm³
Mass	141.8 kg

Table 6:Volume and Mass

Results	deformation	Stress
Minimum	0.mm	3.8558e-004 MPa
Maximum	3.5132 mm	412.35 MPa

Table 7: Deformation and stress

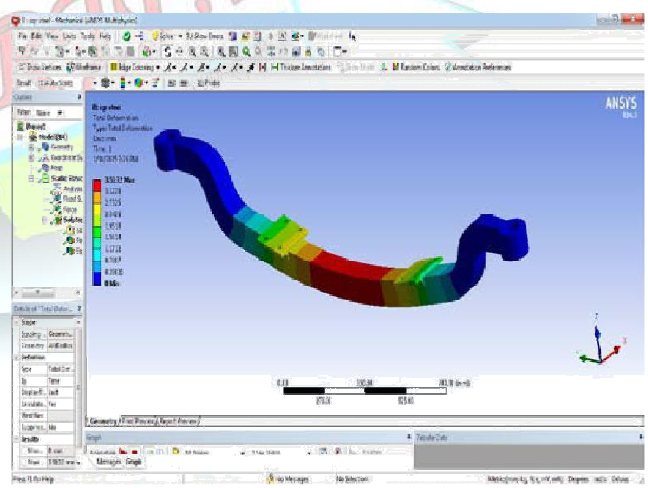


Fig 8:Total Deformation

Volume	1.2307e+007 mm³
Mass	96.61 kg

Table 8:Volume and Mass

Results	deformation	Stress
Minimum	0.mm	1.4515e-004 MPa
Maximum	5.0943 mm	583.56 MPa

3. I SECTION C/S

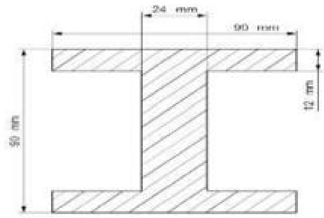


Fig 9: I Cross-section Axle

Fig 10: I cross section

Von Mises stress distribution

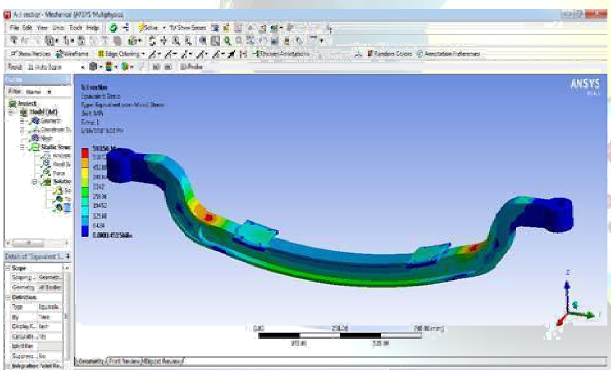


Fig 11:Von Mises stress distribution

Total Deformation

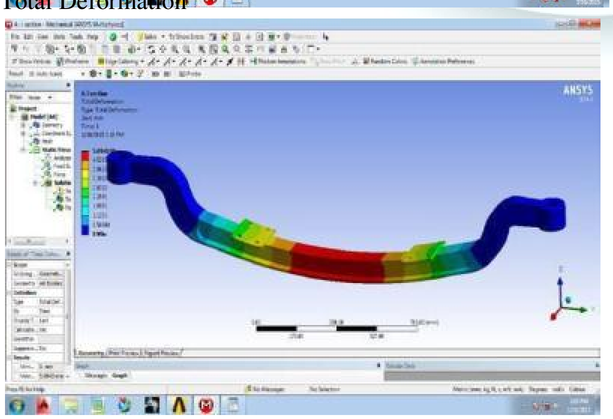


Fig 12:Total Deformation

Comparison of stress and deformation

	SECTION	STRESS (Mpa)	DEFORMATION (mm)	MASS (KG)
1.	Circular	582.51	4.0362	138.14
2.	Square	412.35	3.5132	141.8
3.	I section	583.56	5.093	96.61

Table 10: Comparison of stress and deformation

VI. RESULTS AND DISCUSSION

The results of the analysis of the model that was meshed with elements with maximum deformation 5.093 mm in fig 11 . As seen from the figure the maximum von-Mises stress appear on upper box. From the value of maximum stresses developed in new designed axle are in within limits the minimum cost obtained for I cross section axle of structural steel, the deformation for that axle is 5.093 mm and stresses developed in that axle are Mpa583.56.

VII. Conclusion

This study was conducted on an existing front axle used in truck shows that the existing axle has greater factor of safety so un-wontedly heavy axle is used for truck in existing condition which increase the weight of axle as well as cost of axle. But the newly designed axle with different cross section show that we can maximally reduces the weight as compare to the existing axle shown in comparison table. Also reduces the cost of truck axle as the weight of the axle reduces. The deformations as well as stresses developed in new designed axle are in within limits the minimum cost obtained for I cross section axle of structural steel, the deformation for that axle is 5.093 mm and stresses developed in that axle is Mpa583.56 at 6G force which are in within limit.

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