Analysis and Optimization of Sugarcane Trolley Axle by FEA

Vishal M Bidve[1], Prof. Swami M. C.[2]
[1, 2] Department of Mechanical Engineering
[1, 2] M.S. Bidve Engineering College, Latur, Maharastra, India

Abstract- *In the present market scenario, cost reduction technique is playing a signified role to meet the competition in the market. Weight reduction and simplicity in design are application of industrial engineering etc., are used as source of technique. Various components or products used in rural areas are mostly manufactured in small scale industries such as farming machinery, thrashers, tractor trolleys etc .It has been observed that these rural products are not properly designed. Tractor trolleys are manufactured in small to moderate scale industries. Though tractor trolleys are manufactured of various capacities by various industries, still there is a large variation in manufacturing methods, component design etc. The trolley axle is a central shaft for rotating wheels. The wheels are fixed to the axle, with bearings or bushings provided at the mounting points where the axle is supported. The axle maintains the position of the wheels relative to each other and to the vehicle body.*

In this project work survey is made on sugarcane tractor trolley, during survey it is found that most of axles having bending, deformation, weight, strength problems, and common problem are bending. In this project work analysis is done on axle by finite element analysis using ansys15 for checking bending, deformations and weight optimization by using various materials like MS, SAE1020, etc.

Keywords- Analysis, Trolley Axle, Optimization

I. INTRODUCTION

In India Tractor trolley or trailers is very popular and cheaper mode of goods transport in rural as well as urban area. But these trailers are manufactured in small scale to moderate scale industry. Especially in the small- and middle-scale agricultural machinery industry, insufficient use of new technology and new design features can cause problems such as breakdowns and failures during field operations. The existing trolley designed by the industry uses heavy axle without considering static and dynamic loading conditions which in turn leads to higher factor of safety increasing the overall cost of the axle. In this study, existing trolley axle is redesigned considering the static and dynamic load conditions.

Based on finite element analysis, redesign of axle was carried out for reducing the cost and weight and maintains the mechanical strength with easy manufacturability and cost reduction. Results of static, modal and transient analysis of proposed axle under loading due to modified combine showed that the proposed model is suitable to install on trolley.

In this paper we tried to optimize the hollow axle for the ultimate value so that the strength should bemaintained with the reduction in cost and weight and we find the weight is reduce 40 to 60 %.

Fig:1 typical trolley and its axle unit

The design is optimized based on the manufacturing cost of the axle. The failure analysis is performed on the axle of trolley used in agricultural area. These results provide a technical basis to prevent future damage to the location axle.
In the global competition, it is very important for the manufacturer to bring new product designs to market at a faster rate & also at reduced cost. Front axle beam is one of the major parts of vehicle suspension system; it takes about 35-40% of total vehicle weight. Optimization of axle beam is necessary to improve strength to weight ratio for a given factor of safety without altering any assembly parameters.

The main purpose of the trolley is to provide ahassle-free mode of transporting firewood. The existing designs of trolleys are enormous due to the fact that they need to carry loads of different sizes. It is a known fact, that the mountain dwellers have great skill in stacking up the firewood collected. The objective of this paper to optimize the axle design using finite element analysis method and to validate the design. The main purpose is to reduce the weight of the axle as the axle is the only component who bears the whole load plus the weight of the trolley and then it transfer to the wheel.

In the present market scenario, cost reduction technique is playing a signified role to meet the competition in the market. Weight reduction and simplicity in design are application of industrial engineering etc. are used as sources of technique. Various components or products used in rural areas are mostly manufactured in small scale industries such as farming machinery, thrashers, tractor trolleys etc. It has been observed that these rural products are not properly designed. Tractor trolleys are manufactured in small to moderate scale industries. Though tractor trolleys are manufactured of various capacities by various industries, still there is a large variation in manufacturing methods, component design etc. The urgent issues for industrial companies today are how to reduce the time and cost required for developing a new product. Accordingly, they have tried to use the computer's vast memory capacity, fast processing speed, and user-friendly interactive graphics capability to automate and tie together otherwise cumbersome and separate engineering or production tasks, thus reducing the time and cost of product development and production.

II. LITERATURE REVIEW

This paper deals with static analysis of tractor trolley axle. In India tractor trolley (or) trailers is very popular and cheaper mode for transport of goods and in rural as well as urban areas. Especially various small scale industries are adopting the crude methodologies for designing and manufacturing machine components. One such industry producing tractor trolleys for agricultural use has been identified for this study. Most of the tractor trolley axle used today is rectangular cross section type which in turn leads to increase in the weight of tractor trolley and axle. The solid modeling of axle is developed by CATIA-V5. Analysis is done using ANSYS work bench. In paper an attempt has made by replacing rectangular cross section with circular section. Further static analysis is done to determine von-misses stress, equivalent elastic strain, maximum shear stress, total deformation. Finally the results of rectangular section axle with circular section axle are compared which result in reducing the 20% weight of the circular axle. [1]

In Central India, various small scale industries are adopting the crude methodologies for designing and manufacturing the machine components. One such industry producing tractor trolleys for agricultural use has been identified for this study. The existing trolley designed by the industry uses heavy axle without considering static and dynamic loading conditions which in turn leads to higher factor of safety increasing the overall cost of the axle. In this study, existing trolley axle is comparatively analyzed by considering the static and dynamic load conditions. Tractor trolley or trailers are very popular and cheaper mode of goods transport in rural as well as urban area. But these trailers are manufactured in small scale to moderate scale industry. Especially in the small- and middle-scale agricultural machinery industry, insufficient use of new technology and new design features can cause problems such as breakdowns and failures during field operations. In present work finite element analysis approach is used to make a safer working condition of trolley axle as well as for stress concentration, weight and cost reduction of existing trolley axle.[2]

Tractor trolley (or) trailers are very popular and cheaper mode of goods and transport in rural as well as urban areas. In India, various small scale industries are adopting the crude methodologies for designing and manufacturing machine components. One such industry producing tractor trolleys for agricultural use has been identified for this study. In this paper a static analysis is conducted on a tractor trolley axle. The solid modeling of axle is developed by CATIA-V5. Analysis is done using ANSYS work bench. Most of the tractor trolley axle used today is rectangular cross section type which in turn leads to increase in the weight of tractor trolley and axle. In this paper an attempt has made by replacing rectangular cross section with circular section which result in reducing the weight of the axle and the cost.[3]

The existing Combination axle is safe under the given loading conditions but it involves some problems. It is difficult to manufacture such a design as it needs one hollow shaft and two solid shafts which are inserted into hollow shaft at both ends and then welded for rigidity. A welded joint may fail for prolonged use and on rough roads. It also includes manufacturing difficulties asset is much difficult to fabricate or cast a hollow shaft than solid shaft. The newly designed axle eliminates such problems as it is solid in all. The proposed axle takes less time to produce, so higher production rate is achieved. Further the total weight of combination axle is 56.4 Kg whereas in proposed design it comes to be 49.9 Kg. Thus11.5% reduction in weight is achieved, which results in reduced cost. [4]

In India Tractor trolley or trailers is very popular and cheaper mode of goods transport in rural as well as urban area. But these trailers are manufactured in small scale to moderate scale industry. Especially in the small- and middle-scale agricultural machinery industry, insufficient use of new technology and new design features can cause problems such as breakdowns and failures during field operations. The existing trolley designed by the industry uses heavy axle without considering static and dynamic loading conditions which in turn leads to higher factor of safety increasing the overall cost of the axle. In this study, existing trolley axle is redesigned considering the static and dynamic load conditions. Based on finite element analysis, redesign of axle was carried out for reducing the cost and weight and maintains the mechanical strength with easy manufacturability and cost reduction. Results of static, modal and transient analysis of proposed axle under loading due to modified combine showed that the proposed model is suitable to install on trolley. In this paper we tried to optimize the hollow axle for the ultimate value so that the strength should be maintained with the reduction in cost and weight and we find the weight is reduce 40 to 60 %.The design is optimized based on the manufacturing cost of the axle. The failure analysis is performed on the axle of trolley used in agricultural area. These results provide a technical basis to prevent future damage to the location axle. [5]

Tractor trolley or trailers are very popular and cheaper mode of goods transport in rural as well as urban area. But these trailers are manufactured in small scale to moderate scale industry. Especially in the small- and middle-scale agricultural machinery industry, insufficient use of new technology and new design features can cause problems such as breakdowns and failures during field operations. In Present work finite element analyze is approach is used to modify existing rear axle of tractor trolley. Fatigue failure of the rear axle finite element model was predicted after the dynamic load was imposed on it. For analysis, a 6.0 ton 2 wheeler tractor trolley i.e. Semitrailer manufactured by Awachat Industries Ltd., Wardha is selected. The finite element analysis of existing rear axle of tractor trolley revealed the stresses distribution on rear axle. So, an effort is made to modify the design of existing rear axle along with change of material so that advantage of weight reduction along with safe stress can be obtained. [6]

III. PROBLEM IDENTIFICATION AND PROBLEM DEFINITION

In this project work survey is made on sugarcane tractor trolley, during survey it is found that most of axles having bending, deformation, weight, strength problems, and common problem are bending. Almost all tractor trollies are overloaded as shown in fig 2. Due to this excess loading axle will bend and ultimately fails before the life designed by manufacturer. Bending of axle is shown in following images. In this project work analysis is done on axle by finite element analysis using ansys15 for checking bending stress, strength, deformations and weight by using various materials like MS, SAE1020, Inconel, etc.

Fig. 2 Overloading and bending of trolley axle

Fig. 3 Bending of Axle

IV. OBJECTIVES

1. To find bending stress and strain of sugarcane trolley axle, to overcome the axle bending problem
2. To check strength of axle by static analysis
3. To check the deformations for various material & suggest best one

V. METHODOLOGY

- **Optimization Technique:**

In optimization technique more stress concentrated material will be change by adding or subtracting the material for the purpose of increasing strength of axle and reducing stress concentrated area of axle to avoid the bending without increasing cost of axle.

5.1 Analytical Analysis of Axle

STEP 1: Drawing Free Body Diagram

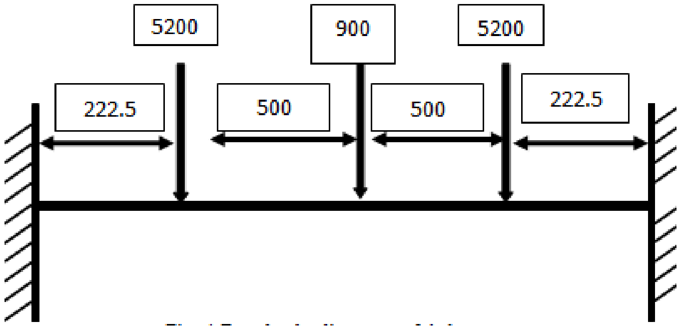

Fig. 4 Free body diagram of Axle

STEP 2: Finding Reaction Forces at support

Submitting forces along vertical direction
$\sum$ FY = 0
RA – 52000 – 900 – 52000 + RB = 0 …...Eq. (1)
Since forces are symmetric,
Reaction on both side is same, hence RA = RB,
Hence by solving equation (1),
RA = RB = 52450 N

STEP 3: Finding Moments at end of beam i.e. MA

Considering any distance X from point A such that $0 \leq X \leq L/2$,
M = (RA*X) + Pc*(X -222.5) - MA,
According to double integration method of beam,

E.I.Y" = M,
E.I.Y" = (RA*X) + Pc*(X -222.5) - MA,
E.I.Y' = (RA + Pc) x2/2 - [(222.5*Pc) + MA]* X + C1, ……………………………………Eq. (2)
E.I.Y = $(R_A + Pc)\frac{X^3}{6}$ - [(222.5*Pc) + M_A]*$\frac{X^2}{2}$+ (C_1*X) + C_2,…………………………Eq. (3)

Boundary Condition
At X=0; Y'=0,
Also X=0; Y=0
Putting above boundary conditions in equation 2 and equation 3
We get,
C1 = C2 = 0,
Putting the value of C1 in equation 2
E.I.Y' = (RA + Pc) x2/2 - [(222.5*Pc) + MA]* X
After applying boundary condition we get,
0 = (RA + Pc) l/2 - [(222.5*Pc) + MA]
Solving above equation and putting values
MA= 2.62 x E7
Since beam is symmetric
MA= MB = 2.62 x E7

STEP 4: Finding Deformation

Solving equation 3 by putting appropriate values in equation
E.I.Y = (RA + Pc) $\frac{X^3}{6}$ - [(222.5*Pc)+ MA]* $\frac{X^2}{2}$+ (C1*X) + C2,

E.I.Y = (52450+ 52000) $\frac{X^3}{6}$ - [(222.5*52000) + 2.62.E7]* $\frac{X^2}{2}$+ (0*X) + 0

Maximum deformation will be at centre i.e. at X=722.5, Hence
E.I.YMAX = (52450+ 52000) $\frac{722.5^3}{6}$ - [(222.5*52000) + 2.62.E7]*$\frac{722.5^2}{2}$+ (0*722.5) + 0
E.I. YMAX= -3.292 x E12
Negative sign shows deformation is downward.

$$YMAX = \frac{-3.292 \times E^{12}}{E.I.}$$
………………………………………………… Eq. (4)

Hence
Axel with Material Steel (E = 205 MPa) and Diameter 80 mm

$$YMAX = \frac{-3.292 \times E^{12}}{E.I.}$$

$$YMAX = \frac{-3.292 \times E^{12}}{4.121 \times E^{11}}$$

YMAX =7.98 mm

Axel with Material Steel (E = 205 MPa) and Diameter 82 mm

$$YMAX = \frac{-3.292 \times E^{12}}{E.I.}$$

$$YMAX = \frac{-3.292 \times E^{12}}{4.55 \times E^{11}}$$

YMAX =7.235 mm

Axel with Material Steel (E = 205 MPa) and Diameter 78 mm

$$YMAX = \frac{-3.292 \times E^{12}}{E.I.}$$

$$YMAX = \frac{-3.292 \times E^{12}}{3.725 \times E^{11}}$$

YMAX =8.838 mm

STEP 5: Stress in Beam

Maximum Stress $\sigma MAX = \frac{y \cdot M_A}{I}$

$$\sigma MAX = \frac{40 \times 2.62 \times E^7}{I}$$

Hence

Axel with Material Steel (E = 205 MPa) and Diameter 80 mm

$$\sigma MAX = \frac{40 \times 2.62 \times E^7}{I}$$

$$\sigma MAX = \frac{40 \times 2.62 \times E^7}{2.01 \times E^6}$$

σMAX= 521.23 MPa

Axel with Material Steel (E = 205 MPa) and Diameter 82 mm

$$\sigma MAX = \frac{40 \times 2.62 \times E^7}{I}$$

$$\sigma MAX = \frac{40 \times 2.62 \times E^7}{2.22 \times E^6}$$

σMAX= 472.21 MPa

Axel with Material Steel (E = 205 MPa) and Diameter 78 mm

$$\sigma MAX = \frac{40 \times 2.62 \times E^7}{I}$$

$$\sigma MAX = \frac{40 \times 2.62 \times E^7}{1.82 \times E^6}$$

σMAX= 576.78 MPa

- **CAD Model:**

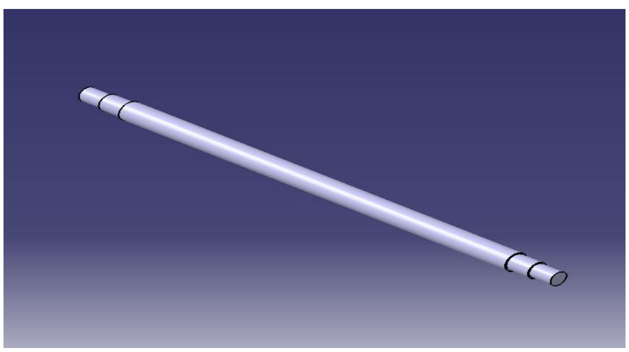

Fig.5 CAD model

- **FEA Model:**

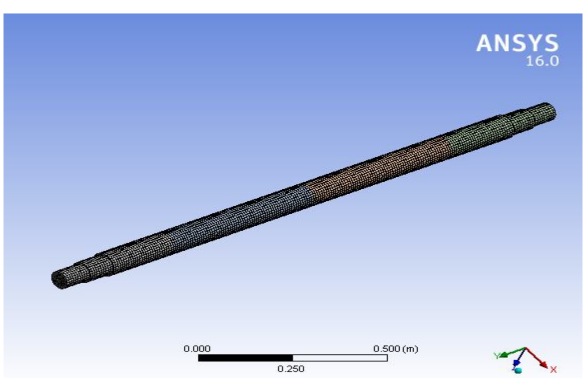

Fig: 6 FEA model of Trolley Axle

Table: 1 No. Nodes & Elements

No. of Nodes	No. of Elements	Type of meshing
142947	40149	Tetrahedron

.

5.2 STATIC ANALYSIS OF TROLLEY AXLE:

- **Procedure For Static Analysis In Ansys:**

1. Build the FE model as explained in chapter 5.1
2. Define the material properties such as young's modulus and density etc.,
3. Apply boundary condition and pressures.
4. Solve the problem using current LS command from the tool bar.

- **ANSYS 16:**

ANSYS Work bench can be thought of as a software platform or framework where you perform your analysis (Finite Element Analysis) activities. In other words, workbench allows you to organize all your related analysis files and databases under same frame work. Among other things, this means that you can use the same material property set for all your analyses. The ANSYS Workbench platform allows users to create new, faster processes and to efficiently interact with other tools like CAD systems. In this platform working on Metaphysics simulation is easy. Those performing a structural simulation use a graphical interface (called the ANSYS Workbench Mechanical application) that employs a tree-like navigation structure to define all parts of their simulation: geometry, connections, mesh, loads, boundary conditions and results. By using ANSYS workbench the user can save time in many of the tasks performed during simulation. The bidirectional links with all major CAD systems offer a very efficient way to update CAD geometries along with the design parameters.

- **SUPPORT AND FORCE:**

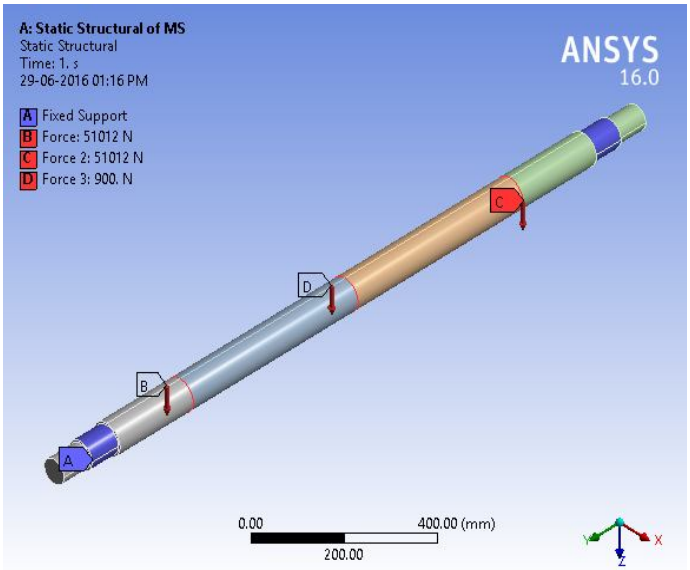

Fig: 7 Support & Force model of Trolley Axle

- **MATERIAL: MS**

- **Material properties of MS Trolley Axle:**

1. Young's modulus E= 210 MPa
2. Poisson's ratio NUXY=0.303
3. Mass density =7860 kg/m3
4. Damping co-efficient =0.008

- **BENDING STRESS:**

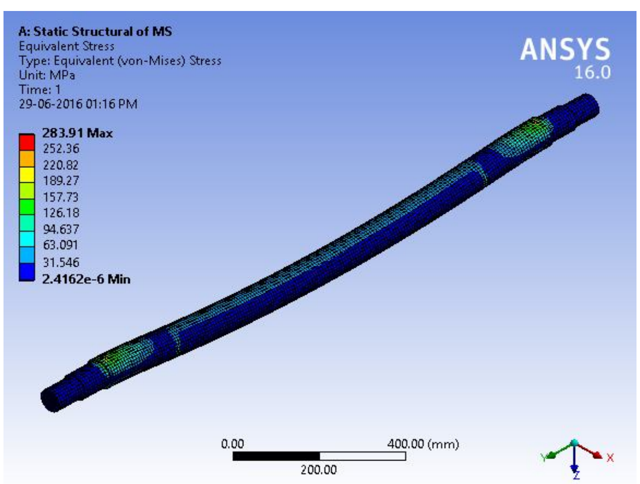

Fig: 8 bending stress of MS Trolley Axle

- **STRAIN:**

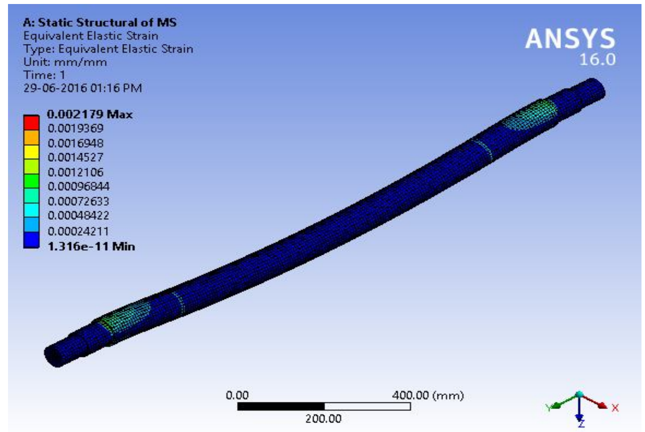

Fig: 9 Strain of MS Trolley Axle

- **TOTAL DEFORMATION**

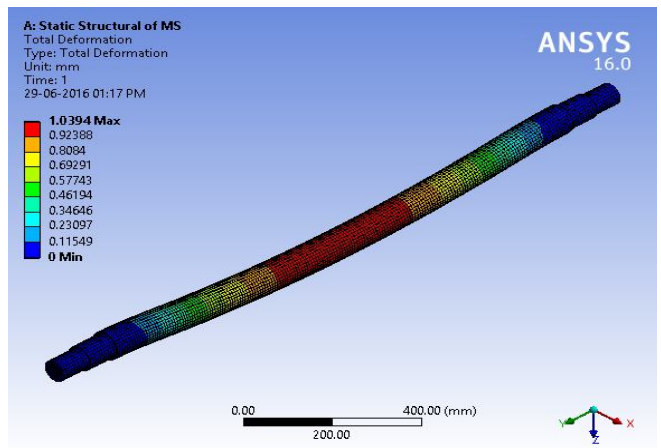

Fig: 10 Total deformation of MS Trolley Axle

- **MATERIAL: SAE1020**

- **BENDING STRESS:**

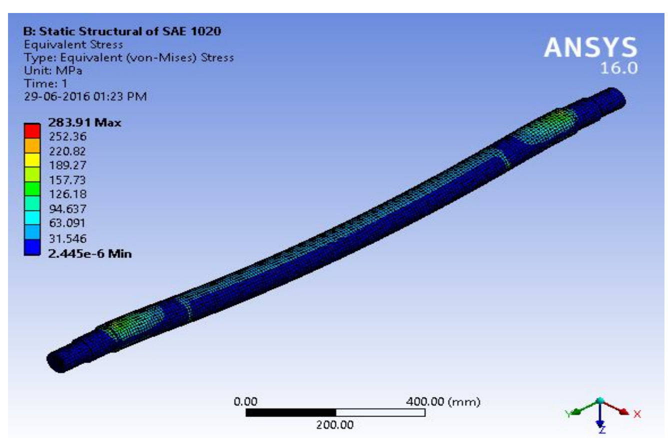

Fig: 11 bending stress of SAE1020 Trolley Axle

➢ **VON-MISES STRAIN**

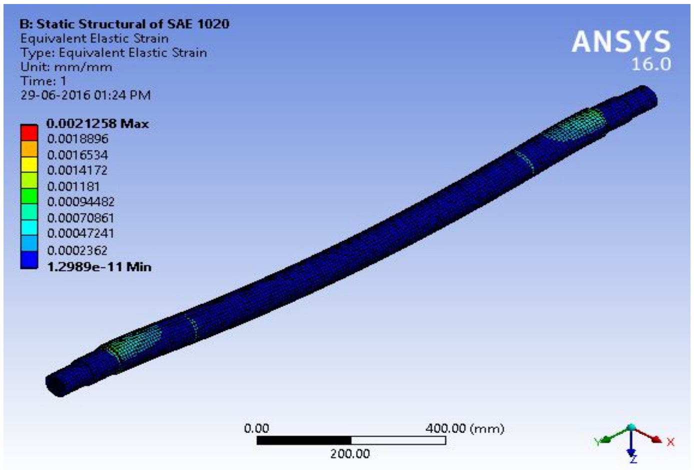

Fig: 12 Strain of SAE Trolley Axle

➢ **TOTAL DEFORMATION**

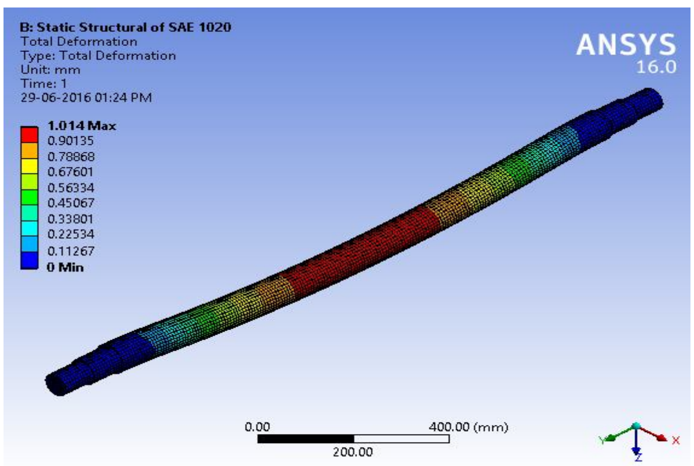

Fig: 13 Total deformation of SAE1020 Trolley Axle

➢ **MATERIAL: INCONEL 625**

➢ **BENDING STRESS:**

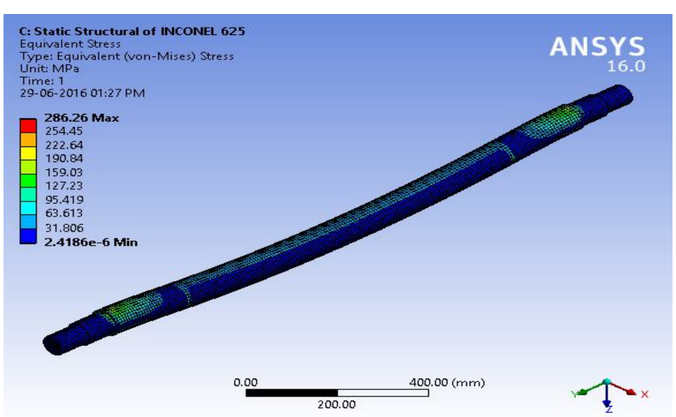

Fig: 14 bending stress of Inconel625 Trolley Axle

➢ **VON-MISES STRAIN**

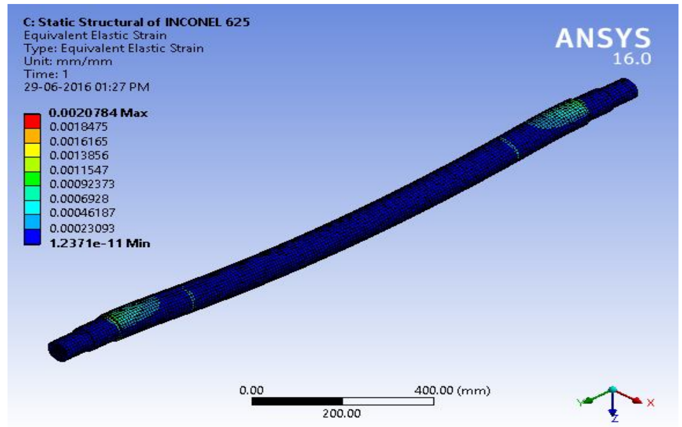

Fig: 15 Strain of Inconel625 Trolley Axle

➢ **TOTAL DEFORMATION**

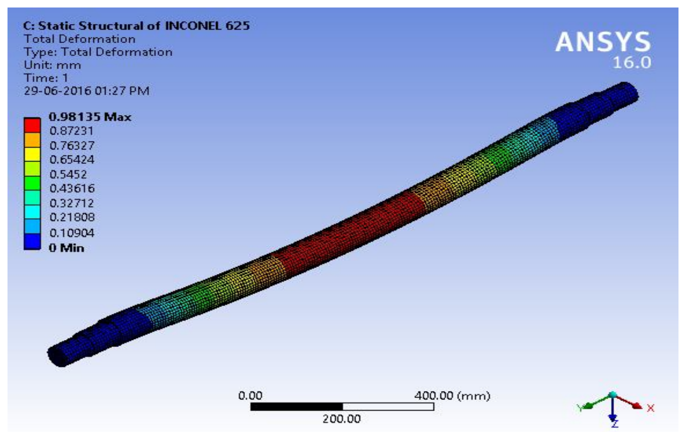

Fig: 16 Total deformation of Incoel625 Trolley Axle

VI. RESULT TABLE

Table 2 Result table

PARAMETER	MILD STEEL	SAE1020	INCONEL 625
STRESS (MPa)	283.91	283.91	286.26
DEFORMATION (mm)	1.0394	1.014	0.98135

VII. CONCLUSIONS

The maximum deflection induced in MS trolley axle is 1.0394mm, which is in safe limits (1% of total span). Hence based on rigidity the design is safe, but if we compare deflections induced in SAE1020 (1.014), it is more in MS. If we use SAE1020 material failure or bending of axle will reduced. The maximum stress induced for both the material is almost same i.e. 286.26 Mpa which is less than the allowable stress (380Mpa).Hence the design is safe based on strength. Compare to MS axle SAE1020 is more rigid & ultimately strength of SAE1020 axle is increases due to its rigidity. At the same time bending stress for Inconel 625 is more & deflection is less.

REFERENCES

[1] P. Manasa, Dr. C. Vijaya Bhaskar Reddy "Static Analysis Of Tractor Trolley Axle Installment" IJETT-volume-4

[2] Manish S Lande and Sunil J Rajpal, comparative analysis of tractors trolley axle by using FEA. (By considering change in materials existing shape & size) ISSN 2278, Vol. 2, No. 3, July 2013

[3] P.Manasa, C.Vijaya Bhaskar Reddy. "Modeling and Analysis of Tractor Trolley Axle Using Ansys", (IOSR-JMCE), Volume 6, Issue 5 (May. - Jun. 2013)

[4] Happy Bansal1, Sunil Kumar, "Weight Reduction and Analysis of Trolley Axle Using Ansys," International Journal of Engineering and Management Research, Vol.-2, Issue-6, December2012.

[5] I.D.Paul, G.P.Bhole, J.R.Chaudhari, "Optimization of Tractor Trolley Axle for Reducing the Weight and Cost Using Finite Element Method" Journal of Engineering, Computers & Applied Sciences (JEC&AS) ISSN No: 2319-5606, Volume 2, No.3, March 2013.

[6] Harish V. Katore, Prof. Santosh B. Jaju, "redesigning of tractor Trolley axle using ansys" International Journal of Engineering Science and Technology (IJEST).