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Design and Analysis of Tractor Trolley Axle by Using CAE Techniques

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Abstract

Tractor trolley (or) trailers are very popular and cheaper mode of goods and transport in rural as well as urban areas. 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. First we have to find out the stresses, deformation and FOS of the existing axle analytically. Then find such shape which is having better properties than existing. Then do the analytical calculation for the suggested shape and find out its weight. Comparison is done on the basis of analytical calculation for existing shape of axle and weight with its suggested material. Then choose such a material which is having good result as compared to the existing one. Last phase of my dissertation is to compare the result of software generated and analytical one and on the basis of the comparison suggest the best possible shape for the present applications. In this work an attempt has made by replacing rectangular cross section with circular section as well as change in the material is also adapted, which result in reducing the deformation & stress of the axle and further the cost of the axle.

Keywords: CAD, CAM, CAE, Tractor trolley

1. Introduction

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. The axle of a tractor trolley is one of the major and very important components and needs to be designed carefully, since 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. Trolley axle under consideration is a supporting shaft on which a wheel revolves. 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 trolley axle is also called as beam axle which is typically suspended by leaf springs

2. Literature Review

P. Manasa et. al. [1] 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 modelling of axle is developed by CATIA-V5. Analysis is done using ANSYS work bench. In their work 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, and 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. Finally, the stress induced in the tractor trolley axle is less than the allowable stress (i.e., 430 MPa). So the design is safe under given loading condition.

Sanjay Aloni [2] in his work finite element analysis 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

Vishwas Lomate et. al. [6] in their work a Dynamic analysis is conducted on sugar cane trolley axle. The solid modelling of axle and analysis is done using ANSYS work bench. Axel is analyzed and studied to solve the problems frequent bending problem of sugarcane trolley of sugar mill. 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. The design is optimized based on the manufacturing cost of the axle. Hollow axle optimized for the ultimate value so that the strength should be maintained with the reduction in cost and weight and weight is reduce 40 to 60 %.

Mr. Harish V. Katore et. al. [5] found that design of axle is not properly done according to the stress analysis, the various type of failure occurs so vehicle owner can't afford the replacement of the axle. Due to the self-weight of axle and improper design failure occurs. As the axle design is not proper and excess material is used to overcome the failure, the self-weight of the axle gets increases to increases the capacity of trolley. Due to which, the cost of the axle also get increases. The self-load of trolley applied on the chassis, leaf spring and axle of the trolley causes failure in dynamic condition. Failure such as breakage of axle hub assembly, axle bending occurs. And these problems are indirectly related to capacity of the trolley. To overcome these problems, a proper redesigning of axle according to the stress strain analysis is required.

Manish S Lande [4] studied weight reduction and simplicity in design are application of industrial engineering etc., the sources of the technique which are used. 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. These products are manufactured as per need, by trial and error methods of manufacturing.

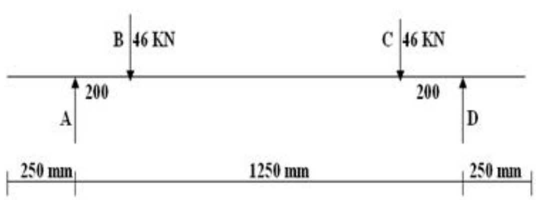


Fig 2.1: Load distribution Diagram for Tractor trolley

Big industrial sectors have not yet entered in manufacturing of these products; hence no significant development in design of rural product has been done so far. In their work theoretical 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.

3. Design of Existing Axle

An axle is a stationary machine element and is used for the transmission of bending moment only. It simply act as a support for some rotating body such as hoisting drum and in tractor trolley case the axle is supporting of rotating member known as hub for holding the tires. So the axles are used to transmit bending moment only. Thus axles are designed on the basis of bending moment only. When the axle is subjected to a bending moment only then we get the following data. [03]

$M/I = (fb)/Y$

M: Bending moment.

I: Moment of inertia.

fb: Bending stress.

Y: Distance of outer fibre from neutral axis.

We can write above equation as,

$z = M / fb$.

As we selected the material for axle is SAE 1020 (Cold rolled) having bending stress - (fb) (Allowable) is 420 MPa.

Maximum Bending moment (M) is found to be 9200000 N-mm.

Hence,

Section modulus (z) = M / fb = 21904.76 mm^3

We know that,

Section modulus (z) = $bh^2/6$. Since h = b

- The obtained value of z = 21904.76 mm^3 = $b^3/6$ = 50.84 mm.
- b = 55 mm

So on the basis of bending moment only we got the cross section of axle as 55 mm.

For SAE 1040 material:

As we selected the material for axle as SAE 1040 (Cold rolled) having bending stress - (fb) (Allowable) is 595 MPa.

Maximum Bending moment (M) is found to be 9200000 N-mm Hence,

Section modulus (z) = M/fb = 15462.18 mm^3

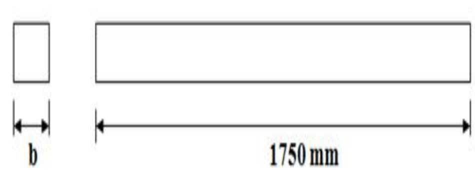
We know that,

Section modulus (z) = $bh^2/6$. Since h = b

- The obtained value of z = 15462.18 mm^3 = $b^3/6$ = 45.27 mm.
- b = 50 mm.

So on the basis of bending moment only we got the cross section of axle as 50 mm.

Square c/s tractor axle



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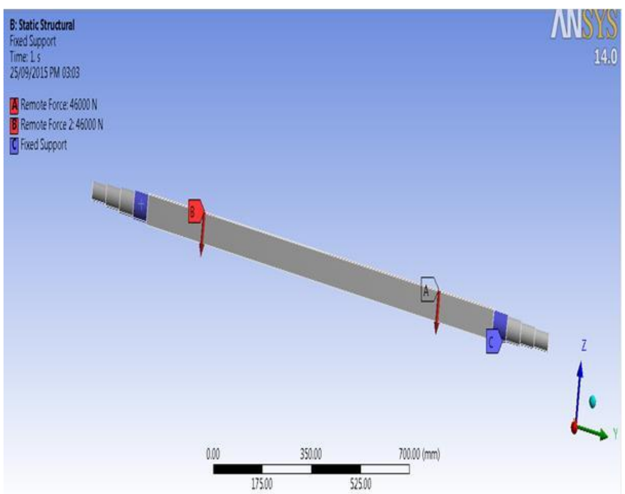
Material: SAE-1020

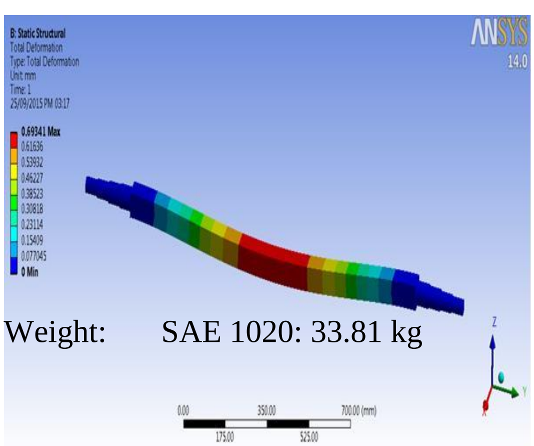
Sut	**420 MPa**
Syt	370 MPa
E	205 GPa
Density	7870 kg/m^3
Poisson's ratio	0.3

SAE 1040

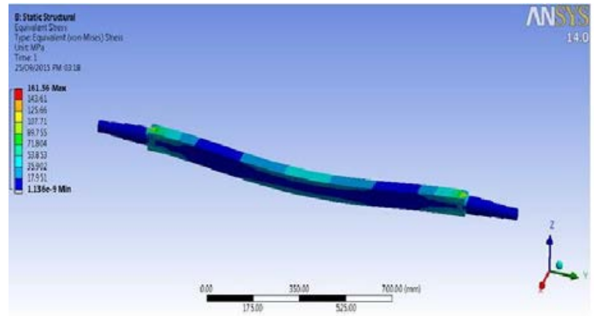
Sut	**595 MPa**
Syt	**515 MPa**
E	**200 GPa**
Density	**7845 kg/m^3**
Poisson's ratio	**0.29**

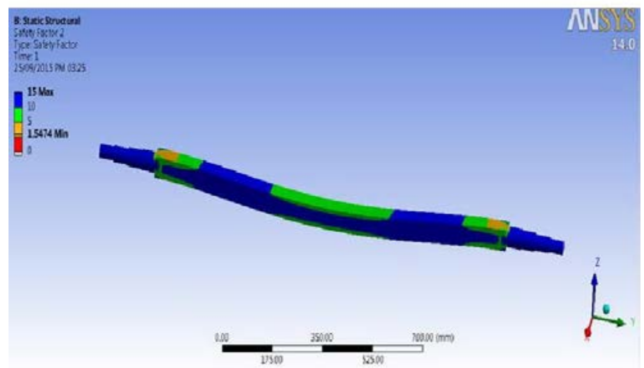
3D Modeling of Square c/s and SAE 1020 material (CATIA)





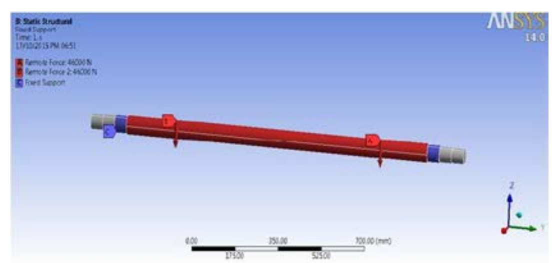
Weight: SAE 1020: 33.81 kg

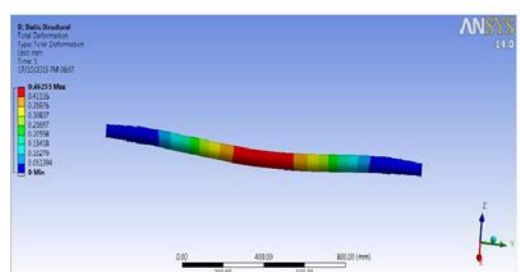


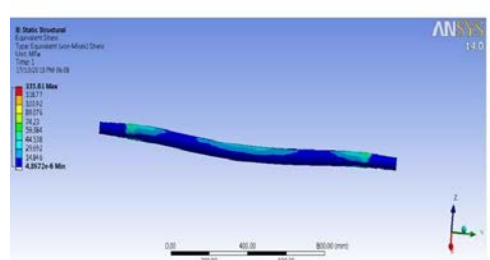


SAE 1040 : 29.612 kg

Analysis for circular c/s and SAE 1020 material







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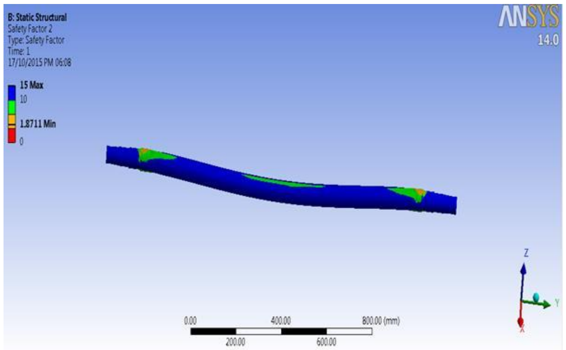

Weight: SAE 1020: 30.247 kg

SAE 1040: 27.102 kg

RESULT & DISCUSSION

Content	Square axle SAE 1020	Square axle SAE 1040	Circular axle SAE 1020
Deformation	0.693	1.0291	0.462
Stress	161.56	173.86	133.61
FOS	1.547	1.437	1.87
Weight	33.81	29.612	30.247

CONCLUSION AND FUTURE SCOPE

Conclusion:

- Circular cross section with SAE 1020 material is having more positive points and less deformation & stress compare to existing square cross section .
- The new selected material is FOS increases through both analytical and software analysis.
- Circular cross sections are comparatively easy to manufacture and also more options are available for circular sections manufacturing.

Future Scope:

- Fatigue Analysis can be consider for detail study.
- Composite material can be tested for optimization.
- NVH analysis can be performed for some special applications

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