Static Analysis of Tractor's Trolley Axle at Different Position of Loading Conditions

Manish S. Lande[1] and Mahesh R. Pundkar[2]

[1]ME (CAD/CAM), Assistant Professor Mechanical Engg. Dept. College of Engineering & Technology Akola, S.G.B.A.University, Amravati, India
[2]ME (CAD/CAM), Assistant Professor Mechanical Engg. Dept. College of Engineering & Technology Akola, S.G.B.A.University, Amravati, India

ABSTRACT

The main objective of this project is to reducing material costs as well as to maintaining the stress levels under the values previously obtained with earlier products that had worked reliable during several years. The main requirements of trailer manufacturing are high performance with good working life and robust construction, the axle of a tractor trolley is one of the major and very important components and needs to be designed carefully, so here the axle is designed by changing the position of loading on axle and find out the optimum position with better factor of safety.

1. INTRODUCTION

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. 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, so ultimately the factor of safety is not keeping properly and it may fails the design otherwise due to high factor of safety its increase the cost of product. In Present work the axle is designed by changing the position of loading on axle and find out the optimum position with better factor of safety.

1. DATA CONSIDERATION

MATERIAL	ULTIMATE STRENGTH (MPa)	YIELD STRENGTH (MPa)	DENSITY (Kg/m3)	MODOLUS OF ELASTICITY (MPa)	POISSONS RATIO
SAE 1020	420	370	7870	205000	0.29

Table 1.1 Basic Data.

General	Single axle, 2-wheeler box type trolley	
Load Capacity	Pay load	60 KN
	Unloaded Weight	13 KN
	Gross load Weight	73 KN
Axle	One square axle is used presently 75*75 mm square of length 1550mm. Weight of axle 0.67 Kg.	
Tire	Two no. of 10" (width) X 20" (radius)	

Table 1.2 Specification of 6-tonne 2-wheeler trolley.

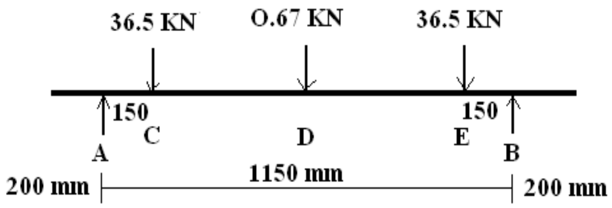
2. DESIGN OF AXLE

2.1 Static Load Analysis

An axle is a stationary machine element and is used for the transmission of bending moment only The total capacity of the trolley is 60 KN but self-weight of trolley and the axle assembly is 13 KN. So we consider the gross weight come over the axle is 73 KN. As the leaf spring is used as the isolator and whole weight of the trolley is mounted over there. Due to leaf spring the total weight of the trolley is transferred over the axle at two point C and E as shown in load distribution diagram.

The procedure adopted for construction of bending moment diagram is as per following:

2.1.1 Consider Distance between Hub and Leaf spring is 150 mm.



LOAD DISTRIBUTION DIAGRAM

The Support reaction is as follows
RA – Support reaction at point A.
RB – Support reaction at point B.

RA = 36.835 KN **RB = 36.835 KN**

Load Point	**Bending Moment**
A	**0 KN-mm**
C	**5525.25 KN-mm**
D	**5667.62 KN-mm**
E	**5525.25 KN-mm**
B	**0 KN-mm**

Table 2.1 Shear force and bending moment on axle for static load.

When the axle is subjected to a bending moment only then we get the following data. By using flexture formulas design the axle.

$$M/I = (f_b)/Y$$

M- *Bending Moment.* **I-** Moment *of Inertia.*

f_b**-** *Bending Stress.* **Y-** *Distance of outer fiber from neutral axis.*

Moment of inertia of cross sectional area of the axle about the axis of rotation

(I) is equal to **2636718.75** mm^4

As we selected the material for axle is **SAE 1020** having bending stress **(f_b)** is **420 MPa.**

Bending moment (**M)** is found to be **29531250 N-mm**

The section modulus **(Z)** of the existing axle **(75 X 75 X 1550** mm^3**)** is found to be

$$Z = M / f_b = 70312.5 \text{ mm}^3.$$

We cross check this section modulus by using data book formulae.

Section modulus (**Z) =** $bh^2 / 6$ = **70312.5** mm^3.

On the observations of the bending moment we found that

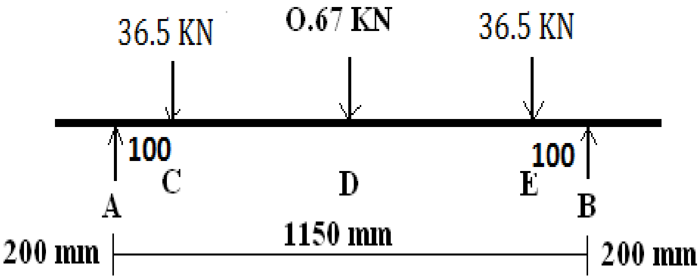
When the axle length and the point load applied on it is considered then the maximum bending moment is found equal to **5667620 N-mm.**

When the material is considered and the cross sectional area is considered then the maximum bending moment is found equal to **29531250 N-mm**

- The maximum moment **(M) = 5667620 N-mm.**
- The bending stress (allowable) **(f_b)= 420 MPa** (SAE 1020)
- Section Modulus **(Z) =** M / f_b **= 13494.33** mm^3
- The obtained value of Z **= 13494.33** mm^3
  Z = $b^3 / 6$ **= 43.26 mm.**
- **b = 45 mm.**

So on the basis of bending moment only we got the cross section of axle is **45 mm**.

2.1.2 Consider Distance between Hub and Leaf spring is 100 mm.



LOAD DISTRIBUTION DIAGRAM

RA = 36.835 KN **RB = 36.835 KN**

Load Point	Bending Moment
A	**0 KN-mm**
C	**3683.50 KN-mm**
D	**3842.62 KN-mm**
E	**3683.50 KN-mm**
B	**0 KN-mm**

Table 2.2 Shear force and bending moment on axle for static load

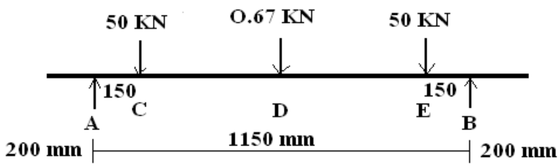
- The maximum moment **(M) = 3842.62 * 10^3 N-mm.**
- The bending stress (allowable) **(f_b)= 420 MPa** (SAE 1020)
- Section Modulus **(Z)** = **M / f_b = 9149.09 mm^3**
- The obtained value of Z = **9149.09 mm^3**
  Z = **b^3 / 6 = 38.00 mm.**
- **b = 40 mm.**

So on the basis of bending moment only we got the cross section of axle is **40 mm**.

2.2 DYNAMIC LOAD ANALYSIS

As we know that the dynamic load is always more than static load but it is not possible to define the accurate dynamic load, so we consider as a maximum load due to dynamic loading is 50 KN on each leaf spring.

2.2.1 Consider Distance between Hub and Leaf spring is 150 mm.



LOAD DISTRIBUTION DIAGRAM

Fig. 4.2 Shear force and bending moment on axle for dynamic load.

The Support reaction is as follows

RA – Support reaction at point A.

RB – Support reaction at point B.

RA = 50.34 KN **RB = 50.34 KN**

Load Point	Bending Moment
A	**0 KN mm**
C	**7551.00 KN mm**
D	**7695.50 KN mm**
E	**7551.00 KN mm**
B	**0 KN mm**

Table 2.3 Shear force and bending moment on axle for dynamic load.

- The maximum moment **(M) = 7695500.00 N-mm.**
- The bending stress (allowable) **(f_b)= 420 MPa**(SAE 1020)
- Section modulus **(Z) = M / f_b = 18322.62 mm^3**
- The obtained value of **Z = 18322.62 mm^3**

(Z) = b^3 / 6

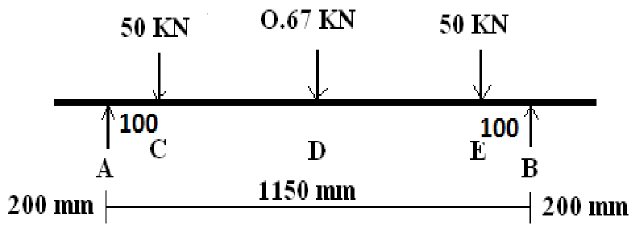
18322.62 = b^3 / 6

b = 47.90 mm.

b = 50 mm.

So by considering the dynamic load condition we obtain the cross section of axle is **50 mm.**

2.2.2 Consider Distance between Hub and Leaf spring is 100 mm.



LOAD DISTRIBUTION DIAGRAM

RA = 50.34 KN **RB = 50.34 KN**

Load Point	Bending Moment
A	**0 KN-mm**
C	**5034.00 KN-mm**
D	**5195.50 KN-mm**
E	**5034.00 KN-mm**
B	**0 KN-mm**

Table 2.4 Shear force and bending moment on axle for static load

- The maximum moment **(M) = 5195.50 * 10^3 N-mm.**
- The bending stress (allowable) **(f_b)= 420 MPa** (SAE 1020)
- Section Modulus **(Z) = M / f_b = 12370.238 mm^3**
- The obtained value of Z **= 12370.238 mm^3**
  Z = **b^3 / 6 = 42.025 mm.**
- **b = 45 mm.**

So on the basis of bending moment only we got the cross section of axle is **45 mm**.

3. PRICE COMPARISON OF EXISTING AND DESIGNED AXLE

1. Weight and Price for Existing Axle of 75*75 cross section made with SAE 1020 material.

   Mass = Volume * Density

   = 0.075*0.075*1.55 * 7870

   = 8.7187 * 10^{-03} * 7870

   = 68.616 Kg.

   Cost = Mass * Price/Kg

   = 68.616 * 40.84

   = **Rs. 2802.10**

2. Weight and Price for Axle of 50*50 cross section made with SAE 1020 material.

   Mass = Volume * Density

   = 0.050*0.050*1.55 * 7870

   = 3.875 * 10^{-03} * 7870

   = 30.496 Kg.

   Cost = Mass * Price/Kg

   = 30.496 * 40.84

   = **Rs.1245.466**

3. Weight and Price for Axle of 45*45 cross section made with SAE 1020 material.

   Mass = Volume * Density

   = 0.045*0.045*1.55 * 7870

   = 3.1387 * 10^{-03} * 7870

   = 24.702 Kg.

   Cost = Mass * Price/Kg

   = 24.702 * 40.84

   = **Rs. 1008.828**

Table 3.1 shows the price comparison between recently used axle and Designed axles.

C/S	Distance between Hub and Leaf spring	MASS(Kg)	COST(Rs.)
75*75*1550mm *EXISTING*	150 mm	68.616	**2802.10**
50*50*1550mm *DYNAMIC OLD*	150 mm	30.496	**1245.466**
45*45*1550mm *DYNAMIC NEW*	100 mm	24.702	**1008.828**

4. CONCLUSION

From the above discussion and mathematical calculations we can conclude that, if the distance between Hub and Leaf spring is vary from 150 mm to 100 mm, there is reduction in bending moments, ultimately it reduce the cross sectional area of axle as well as weight and price.

REFERENCES

[1] "Comparative Evaluation of Tractor Trolley Axle by Using Finite Element Analysis Approach" Sanjay Aloni G(M.Tech CAD/CAM) Student of Department of Mechanical engineering, YCCE, Nagpur. Sandip

Khedkar Asst. Prof., Department of Mechanical engineering, YCCE, Nagpur

[2] "Redesigning of Tractor Trolley Axle Using Ansys" Mr.Harish V. Katore, Prof. Santosh B. Jaju. Department of Mechanical Engineering, G. H. Raisoni College of Engineering, Nagpur.

[3] Reducing the Weight of a Frontal Truck Axle Beam Using Experimental Test Procedures to Fine Tune FEA. N. León *, O. Martínez, P. Orta C., P. Adaya ITESM, Campus Monterrey, Sucursal de Correos "J", Monterrey, N.L. Mexico

[4] Comparative Analysis of Tractor's Trolley Axle by using fea. (by considering change in materials existing shape and size) Manish S Lande1* and Sunil J Rajpal1 *Vol. 2, No. 3, July 2013 © 2013 IJMERR.*

[5] "Bending Stress Analysis of Rear Axle of Maruti-800 Car", Kalpan Desai, Mukesh Kanungo, Bharat Gupta and Madhikar M M (2012), *International Journal of Engineering Research & Technology (IJERT)*, ISSN: 2278-0181.

