IJARSE
ISSN: 2319-8354

Design and Analysis of Axle for Improved Stability of Bullock Cart

Shinde Amarsinh Ravindra[1], M. M. Mirza[2]

[1]*PG Student, Department of Mechanical Engineering,*
Rajarambapu Institute of Technology, Sakharale, (India)
[2]*Asst. Professor, Department of Mechanical Engineering*
Rajarambapu Institute of Technology,Sakharale, (India)

ABSTRACT

In India, most of the people use bullock cart for the transportation of sugarcane from the farm to the respective sugar industry. Bullock carts are very popular and cheaper mode of goods transport in rural area. But these bullock carts are manufactured in small scale to moderate scale industry. During manufacturing insufficient use of new technology and new design features results in problems such as breakdowns and failures during field operations. The existing bullock cart Axle 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 present work, existing bullock cart axle is redesigned considering the static and dynamic load conditions. Minimum cross section for the axle is calculated which resulted in the 48 % reduction in the weight of the axle. The weight of axle is reduced without compromising with existing hub assembly of wheel. In traditional bullock cart axle is horizontal. In present work shape of axle changed to U shape .Due to this Change in shape of axle the distance of C.G. gets reduced. The momentum created about the wheel also gets reduced and also the reaction on the bullock neck is decreased.

Keywords— Bullockart, Force Analysis, Bending Stress, Axle.

I. INTRODUCTION

India is an agricultural country where more than 70% of the people depend on agriculture as their main income source. For the agricultural purpose and for the transport of grains from the farm to the home or from the farm to the market the farmer use bullock cart as it is the easiest and economical source of transport.

In Maharashtra, most of the people use bullock cart for the transport of sugar-cane from the farm to the respective sugar industry. There are over 13 million of animal driven carts in India. Most of which are two wheel carts drawn by two bullocks. . Bullock carts are the main source of transport for rural areas in India. No investigation has been carried out by the manufacturers so far as the dimension of the bullock Cart is considered.

There are no any scientific reasons for the particular dimensions of the bullock cart. The dimensions of the bullock cart vary region to region and there are carts having different dimensions used in the same region. The high proportions of these carts are fitted with rigid (wooden) wheels using mild steel bearings and a mild steel axle. However the wheel shows a large variation in the diameter, width, shape, size and width in the different parts of the country. The variations in the dimensions are decided by the conventional manufacturing and it has no much scientific base. Aggregate investment on bullock cart is alone order of 3000 corers in India. Bullock carts are used for the 80% of the total transport of the Indian farm produce.

Bullock carts are developing centuries ago and have considerable technological improvements, while the terrains on which they are used are changed considerably. In the survey carried out in the nearby regions we have found out that people using the bullock carts are willing to change the cart and use better and improved cart.

II. HISTORY

In the early days of Kampongs in Singapore, bullocks with large humps and flapping dewlaps were a common sight and often reared. They powered wheeled vehicles that moved up and down cart that would later develop into proper roads. This large two-wheeled vehicles pulled by a pair of bullocks were often hired as freight. The freight included water, hay, coconuts, pineapples, and simple furniture when people moved. Kreta Ayer, literally meaning “bullock cart water” in Malay, is a road in Chinatown which draws its name from the bullock and ox carts that used to ply this road carrying water for the early inhabitants of Singapore.

III. CURRENT SCENARIO

In India, most of people use bullock carts for transportation of sugarcane from the farm to the respective sugar industry. Bullock carts are very popular and cheaper modes of goods transport in rural as well as urban areas. But this bullock carts are manufactured in small scale to moderate scale industry. However the traditional Indian wooden bullock carts faces following problems:

During manufacturing insufficient use of new technologies and new design features results in problems such as breakdowns and failure during field operations.

There are many problems which occur during transportation of bullock cart. The following failures are observed in the bullock carts from the survey of bullock carts at Rajarambapu Patil Sahakari Sakhar Karkhana Ltd, Sakharale.

- Axle failure
- Yoke failure
- Failure of various joints
- Puncture problem
- Shifting of Centre of Gravity

Traditional bullock carts are not durable (they have life less than 25 years) which deteriorates the economy to the farmers or poor people for whom the bullock carts are livelihood. In traditional bullock carts animal energy is not used to its fullest potential. It has less load carrying capacity with maximum energy loss.

Since there is a domination of traditional bullock carts all of this above problems is ignored and there is no scope for development in this field. Wood is used as main material for manufacture of traditional bullock cart, hence there is more deforestation.

IV. NEED OF IMPROVEMENT IN AXLE FOR BULLOCK CART

Since main aim is to design an axle for improved stability of bullock cart so there are following needs which are to be met in order to design a satisfactory model of axle for bullock cart:

Improved axle of bullock carts will be durable (more than 25 years) which will provide better economy to the farmers or poor people for whom the bullock carts are meant for livelihood. As scientifically produced source of energy (fossil fuel) is depletable, use of animal energy should be increased as much as possible. It will help to increase the transportation of agriculture products with minimized loss. Deforestation will be reduced as the improved carts will use steel as the main material.

V. ADVANTAGES OF IMPROVED AXLE DESIGN

I section axle is used in improved axle of bullock cart which reduces the material as compared to square section axle. Because of U shape of axle, the distance between C.G. and Centre line of wheels get reduces which results reduction in neck load and pulling force. Due to lower C.G. stability of cart is increases at various inclined roads.

VI. LITERATURE REVIEW

Relating to the current stated work a literature survey was carried out. The summary of the reviewed papers is given below.

M. R. Raghavan and H. R. Nagendra [1] have carried out engineering analysis of the design of two-wheel bullock carts with the aid of a mathematical model. Non-dimensional expressions for the pull and the neck load have been developed. In the first instance, the cart is assumed to be cruising at constant velocity on a terrain with the effective coefficient, of rolling friction varying over a wide range: 0.001 to 0.5 and the gradient varying between + 0.2 to - 0.2. Subsequently, the effect of inertia force due to an acceleration parallel to the ground, is studied. In the light of this analysis, two modifications to the design of the cart have been proposed and the relative merits of the current designs and the proposed designs are discussed.

M. R. Raghavan and D. L. Prasannarao [2] has carried out work regarding a cart fitted first with pneumatic wheels and then with steel-rimmed wooden wheels was tested on three terrains tar road, mud road and grassy terrain. Pull vs time and moment vs time records were obtained in each test and analyzed. It is found that the bullocks pull the cart rather discontinuously at the low velocities at which these carts normally operate. On the tar road and the grassy terrain, the mean static coefficient of friction is significantly higher for the cart with steel rimmed wooden wheels. The dynamic frictional resistance of the terrain for the cart with steel-rimmed wooden wheels is lower than for the cart with pneumatic wheels so long as the wheels do not dig or sink into the terrain. The fluctuation in the neck load is lower in the cart fitted with pneumatic wheels. Also, the ground-induced low amplitude high-frequency vibratory load content in the neck load is lower in the cart with pneumatic wheels.

T. P. Ojha and A. C. Pandya [3] have studied the performance of rigid model wheels in the laboratory on two deformable surfaces (sand clay loam and sand). On the basis of the results obtained it was possible to predict the performance of full size wheels. This was verified by trials with a prototype wheel of 60 in dia. and 26 in rim.

S. D. Deshpande and T. P. Ojha [4] was developed improved bullock cart based on survey and testing of traditional and pneumatic-tired carts. An improved cart is provided with a braking system, proper balance, a steel axle, increased carrying capacity, quicker access for lubrication, seating arrangements for passengers, and provision for carrying low-density material like husk, straw, etc. The performance evaluation studies revealed that the carrying capacity of this cart is 12 quintals (1200 kg) on loose field terrain, and that the draft required is 125 kg (1.2 kN). An improved bullock-cart gave better results than a traditional cart in respect of draft and power requirements.

Mulani Nawaj and Mirza M. M. [5] were carried out FEA analysis of bullock cart axle under static and dynamic condition. Existing bullock cart axle is redesigned considering the static and dynamic load conditions. Minimum cross section for the axle is calculated which resulted in the 22.5 % reduction in the weight of the axle. The weight of axle is reduced without compromising with existing hub assembly of wheel.

VII. ASSUMPTIONS FOR DESIGN CALCULATIONS

Track width of cart = 1500 mm

Platform width of cart = 1100 mm

Platform length of cart = 2200 mm

Volume of cart = Weight / Density of Sugarcane

$= 3000/400 = 7.5\ m^3$

Height of cart = V/(L*W) = 3.09 m

For static condition,

Weight of loaded cart = 3000 kg

Self-weight of cart = 500 kg

Total weight of cart = 3500 kg

For dynamic conditions,

Total weight = 2*Weight in static condition

= 2*3500 = 7000 kg

VIII. DESIGN OF AXLE

Material used for axle is SAE 1025. Material specifications as given below-

SR. NO	SPECIFICATION	VALUE
1.	Density	7.858 g/cm^3
2.	Poisson's Ratio	0.27 to 0.30
3.	Modulus of Elasticity	190 to 210 Gpa
4.	Tensile strength	440 Mpa
5.	Yield strength	370 Mpa

Table 1. Material specification for axle

To calculate the reaction forces on axle we consider axle as simple beam. The load acting on beam is 7500 Kg.

Load in Newton = 7500 * 9.81 = 68670 N

Summation of all vertical forces is zero

RA + RB = W

RA + RB = 68670 N …….. (1)

Taking moment about point A.

RB × 1500 = (1300W+200W) / 2

RB = (68670 / 2)

RB = 34335 N

Putting these value in eq^n (1), we get,

RA = 34335 N

Load point	Shear force (N)	Bending moment(N-mm)
A	34335	0

C	0	6867000
D	0	6867000
B	-34335	0

Table 2. Shear force and Bending moment

We design the axle for three sections.

1) Solid Square Section
2) Hollow Square Section
3) I-Section

8.1 Solid Square Section

By using flexure formula,

$\frac{M}{I} = \frac{\sigma b}{y}$

For Conventional Bullock Cart, solid square section is 58mm×58mm

Permissible stress=$\frac{Syt}{FOS} = \frac{370}{1.5}$ = 246 MPa

Z=section Modulus=$\frac{I}{y} = \frac{(bd^3/12)}{(d/2)}$

$= \frac{(58\times58^3/12)}{(58/2)}$

$Z_{current}$ = 32518.67 mm^3

$\sigma_b = \frac{M}{Z}$

246 × Z = 6867000

$Z_{required}$ = 27914.63 mm^3

32518.67 > 27914.63

$Z_{current} > Z_{required}$

Hence, required section modulus can be reduced to 27914.63 mm^3 for permissible strees of 246 MPa.

Volume = Area × Length

= (58×58)×1500

= 5046000 mm^3

Mass = Volume × density

= 5046000 × 7.858×10^{-6}

= 39.6515 Kg

8.2 Hollow Square Section

Z=section Modulus=$\frac{I}{y}=\frac{(BD^3-bd^3)}{(6D)}$

27914.63=$\frac{(58\times58^3-bd^3)}{(6\times58)}$

bd^3 = 1602204.76 ……….but (b = d)

d^4 = 1602204.76

d = 35.57 mm ≈ 35 mm

b = 35 mm

Thickness = (D-d) / 2

= (58-37) / 2

= 11.5 mm

Volume = [(58×58) - (35×35) + (π/4)×35^2] ×1500

= 4651669.125 mm^3

Mass = 4651669.125 × 7.858×10^{-6}

= 36.5528 Kg

Reduction in Mass = (39.6515-36.5528) / 39.6515

= 0.0781

= 7.81%

8.3 I - Section

$I_{xx}= 2*\{\frac{(bd^3)}{12}+\frac{(b\times d)(b+d)^2}{4}\}+\frac{(db^3)}{12}$

$=\frac{(bd^3)}{6}+\frac{(db^3)}{2}+\frac{(b^2d^2)}{1}+\frac{(bd^3)}{2}+\frac{(db^3)}{12}$

$=\frac{2(bd^3)}{3}+\frac{7(db^3)}{12}+\frac{(b^2d^2)}{1}$

Assuming (b/d) =4

$I_{xx}=\frac{2\times4d^4}{3}+\frac{7\times64(d^4)}{12}+\frac{16\times d^4}{1}$

$I_{xx}=56d^4$

Z=section Modulus = $\frac{Ixx}{y}=\frac{56d^4}{\left(\frac{b}{2}\right)+d}$

$=\frac{56d^4}{\left(\frac{4d}{2}\right)+d}$

27914.63 = $\frac{112d^4}{6d}$

d=12 mm

b=48 mm

Volume = (3×48×12) ×1500

$= 2592000\ mm^3$

Mass = $2592000 \times 7.858 \times 10^{-6}$

$= 20.37$ Kg

Reduction in Mass= (39.6515-20.37)/39.6515

= 0.4863

= 48.63 %

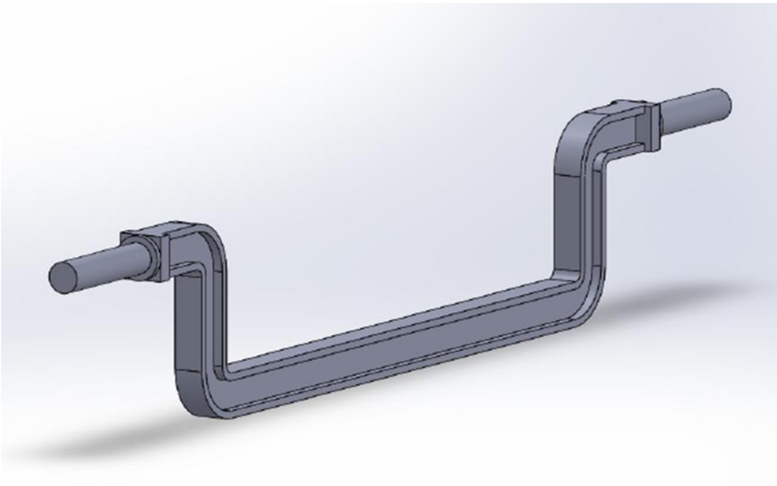

Figure 1 CAD Model of Axle

IX. CONCLUSION

9.1 Effect of I- Section Axle

I section has better bending failure resistance because of its section modulus. By using I section for axle we can reduce 48.63 % material as compared to standard square section.

9.2 Effect of U Shape Axle

In traditional bullock cart axle is horizontal. Here I have changed the shape of axle to U shape .Due to this Change in shape of axle the distance of C.G. gets reduced. The momentum created about the wheel also gets reduced and also the reaction on the bullock neck is decreased.

9.3. Future Scope

India is an agricultural country where more than 70% of the people depend on agriculture as their main income source. For the agricultural purpose and for the transport of grains from the farm to the home or from the farm to the market the farmer use bullock cart as it is the easiest and economical source of transport. So we can used this improved bullock cart as it reduces the effort required to pull the bullock and the load on the bullocks neck get reduced. This cart is helpful to transport the sugar cane by doing some optimization in design.

REFERENCES

1. M. R. RAGHAVAN and H. R. NAGENDRA, A study on bullock carts.
Part 1. Engineering analysis of the two-wheel bullock cart design, Proc. Indian Acad. Sci., Vol. C 2, Part 4, December (1979), pp. 435-449.

2. M.R. RAGHAVAN and D. L. PRASANNA RAO, A study on bullock carts. Part 2. Experimental study of forces in a bullock cart, Prec. Indian Acad. Sci., Vol. C2, Part 4, December (1979), pp. 451-471.

3. T. P. OJHA and A. C. PANDYA, Optimum Size of Bullock Cart Wheels, Journal of agricultural Engineering & Research. (1968) 13 (2), pp. 134-140.

4. S. D. DESHPANDE and T. P. OJHA, Development and Evaluation of an Improved Ox-Cart for Central India, Journal of Terramechanics, Vol. 22, No. 3 (1985), pp. 135-146.

5. MULANI NAWAJ. A and MIRZA M. M. FEA Analysis of Bullock cart Axle under Static and Dynamic Condition, ISSN (Print): 2321-5747, Volume-1, Issue-2, (2013)