INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN: 2278 – 0211 (Online)

Failure Analysis Of Rear Axle Of A Tractor With Loaded Trolley

A. K. Acharya
Temple City Institute Of Technology And Engineering, Khurda, Odisha, India
I. Panigrahi
KIIT University, Bhubaneswar, Odisha, India
P. C. Mishra
KIIT University, Bhubaneswar, Odisha, India

Abstract:
This paper describes the failure analysis of the rear axle at the root of the spline of a tractor with a loaded trolley used for haulage operation. The analysis has been made using the principles of mechanics. The reason behind the failure has been found to be the weight transfer from front to rear, reduction of which is considered to be a remedial measure for the occurrence failure.

Key words: *Failure analysis; Wight transfer; Haulage operation; hitching point*

1.Introduction

The term 'Tractor' is derived from 'Traction' as a it pulls a load. The engine, gearbox, the differential and the rear axle carriers are connected directly with each other in a tractor so as to form a single unit. Since tractor is meant for pulling a load, it is designed to deliver comparatively higher torque and lower speed. In addition to significant multiple applications in the field of agriculture, tractors have many fold commercial applications such as haulage operation in sand mining, laser leveler applications, driving an alternator through PTO (Power Take Off) shaft, running compressors, loader applications and so on. It is pertinent to note that in India higher HP tractors (60 HP and above) are proving to be more and more useful for commercial purposes.

A common and noticeable phenomenon is the failure of the rear axle of a tractor during the haulage operations while carrying heavy loads in the trolley. For example the failure of rear axle is quite likely to occur during the course of sand mining operation where sand is transported by a tractor from the river bed for construction purposes. In such kind of operation the tractor is used with a trolley to carry the sand. During this operation the tractor has to operate in highly adverse road conditions and is required to pull a load of the order of 20 to 27 tones. Normally higher HP Tractors are preferred in this kind of operations.

The failure analysis of rear axle shafts of Mahindra 575 DI and that in the case of automobiles has been studied in [1] and [2] respectively. In addition to these some more references in this direction are [3] -[6]. Though the rear axle failure in case of a tractor is of immense concern, no sufficient work has been undertaken related to it (cf. [7]).

The objective of the present paper is to consider and analyze the failure of the axle occurring on the root of the spline of the rear axle of a tractor used with a loaded trolley for haulage purposes within a span of 600 to 1000 hours of operation and the recurrence of such failure even after replacement of the failed component. The analysis has been made from the point of view of mechanics and certain simple feasible measures have been proposed for preventing the failure.

2.Analysis Of The Problem

During the forward movement of a rear wheel drive tractor with a drawbar pull, a weight transfer from the front wheel to the rear wheel ensues. As a result of this the front wheels develop poor ground contact as compared to the rear wheels and the tractor tends to get lifted up from the front (Figure – 1). When the front wheel gets lifted up the steering does not respond to the operator. Such an occurrence is risky and prone to accidents. As a consequence of the lifting of the front wheel the entire weight of the tractor along with the torsional driving load acts on the rear axle. Due to repeated application of the above loads on the rear axle, the axle fails within a span of 600 to 1000 hours of operation because of fatigue (Figure-2). The pattern of the splines of the failed shafts at the root of the spline indicates the effect of the torsional load.

Figure 1

Figure 2

The different type of loads acting on the rear axle is the following.
(i) Torsional load, (ii) The self weight of the tractor.
When the front end of the tractor gets lifted up, since the total weight of the tractor acts on the rear axle, there is an increase in the load as mentioned in (ii) above.

3.Mathematical Modeling
The free body diagram for analyzing the problem is depicted in figure – 3.

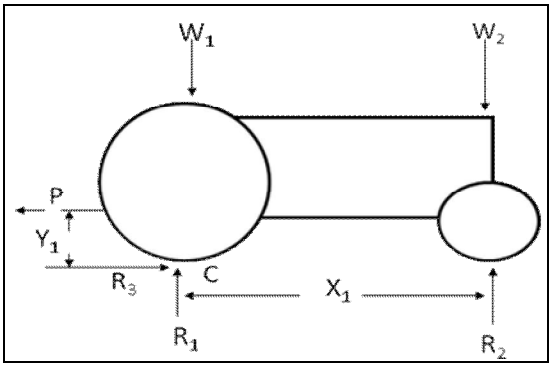

Figure 3

W_1, W_2 = Weights on rear and front wheel respectively.
P= Horizontal pull because of the loaded trolley.
Y_1 = Height of the hitching point.
R_1, R_3 = the vertical and the horizontal components of the soil reaction at the rear.
R_2 = Vertical soil reaction at the front.
X_1 = Wheel base

Assumption: The tractor has a uniform forward motion (acceleration is zero) on a level surface.
For the dynamic equilibrium of the tractor the algebraic sum of all the horizontal forces as well as that of all the vertical forces should be equal to zero. In addition, the sum of the turning moments of all external forces about the moment center 'C' should be equal to zero. This leads to the following.

$$R_3 - P = 0, \quad (1)$$
$$R_1 + R_2 - W_1 - W_2 = 0, \quad (2)$$
$$W_2 X_1 - PY_1 - R_2 X_1 = 0. \quad (3)$$

Solving the system of linear equations (1), (2) and (3) we get,

$$[R_1 \quad R_2 \quad R_3] = [\, W_1 + PY_1 / X_1 \quad W_2 - PY_1 / X_1 \quad P \,] \quad (4)$$

The factor 'PY_1 / X_1' is known as the weight transfer factor and equation (4) reveals that the soil reaction R_1 at the rear increases by the amount of the weight transfer factor and R_2 at the front decreases by the same amount. Thus it is evident that due to weight transfer the soil reaction at the rear wheel increases and that at the front wheel decreases, resulting in the instability and the lifting of the front

wheel. Since with the lifting of the front wheel the load on the rear axle increases, in order to decrease the load on the rear axle it is necessary to decrease the weight transfer factor.

The value of '$PY1 / X_1$' can be reduced in three different ways as mentioned below.

- By increasing the value of X_1.
- By decreasing the value of P.
- By decreasing the value of Y_1.

The option (a) is not acceptable as it will involve lots of design related changes in the tractor and is difficult to be implemented. Similarly option (b) is also not acceptable since it will affect the financial earnings of the customer. Therefore, option (c) is the only feasible alternative, which is the reduction of Y_1, the height of the hitching point.

4.Concluding Remarks

Lifting of front wheel is quite risky where the first victim is the operator. As a matter of fact many human lives have been lost because of this. The front wheel lifting and the failure of the rear axle at the root of the spline though mainly due to the transfer of weight, not sufficient attention have been given for remedying the issue. One of the authors of the present paper had implemented the proposal of reducing the hitching height (Y_1) and it was observed that by reducing the hitching height to 16.00 inches (which is normally taken as 19 to 20 inches) remarkable results were obtained so far as the lifting of the front wheel and the failure of the rear axle are concerned. The above reduction in the hitching point height will result in a reduction in the weight transfer factor by nearly 20%. However, the reduction in the hitching point height along with the modifications as suggested in [1] can certainly be more beneficial in controlling the lifting the front of the tractor and the consequent failure of the rear axle. Finally it is claimed that the mechanistic approach which has been adopted in this paper for this problem is considered to be most conducive as whether it is an automobile or a tractor, the problem is a dynamic in nature.

5.References

1. Nanaware GK, Pable MJ. Failure of rear axle shafts of 575 DI tractors. Engineering Failure Analysis 2003;719-724.
2. Osman Asi. Fatigue failure of a rear axle of an automobile. Engineering Failure Analysis 2006;1293-1302.
3. Amol Bagate, Aher VS. Axle Shaft Torsional Fatigue Life Expecancy Proc.NCNTE-2012, Third Biennial Na.Conference on Nascent Tech, Mumbai, 119-126.
4. Tarighi Javad, Seyed Saeid Mohtasebi, Reza Alimardani. Static and ynamic analysis of front axle housing of tractor using finite element analysis. AJAE 2(2) 2011; 45-49.
5. Khangar VS, Jaju SB. A review of various methodologies used for shaft failure. Int. J. Engineering Technology and Adv. Engg., 2(6) 2012, 50-54 2012.
6. Guo, T. and Wang, Y., Study on repair Fatigue Damage of Ale Shaft Mechanical Parts. Second Int. Conference on Inform. and Comput. Sci.(IEEE), 2009, 264-267.
7. Celik, H.K., Yilmaz, D., Unal, N.and Aknic, I., Falure analysis of a location axle in tracked tractor, J. Fail. Anal. and Preven., 9, 2009, 282-287